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Phytosociological research on temporary ponds in Apulia (southern Italy)

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Abstract. The ephemeral hygrophilous vegetation occurring in the temporary ponds of Apulia (southern Italy) was studied following the phytosociological approach. On the base of 153 phytosociological relevés carried out during the period 2015-2018, 19 associations were identified, of which 16 described for the first time. All the associations belong to the *Isoeto-Nanojuncetea* class. The surveyed associations can be arranged in two orders, such as *Isoetetalia,* including those with a winter-spring cycle and *Nanocyperetalia,* regarding those with a summertime cycle. The identified associations have been examined in detail, and for each one, we provided a phytosociological table. The communities belonging to the *Isoetetalia* are 17 and arranged in four alliances (*Isoetion*, *Preslion cervinae*, *Cicendio filiformis-Solenopsion laurentiae*, *Agrostion salmanticae*); instead, those ones of *Nanocyperetalia* are two both included in the *Verbenion supinae.* In order to highlight the relationships among the associations, all the relevés used for this investigation are processed. Overall, this analysis confirms the autonomy of the associations, grouping them according to the syntaxonomic arrangement proposed by the authors. Taxonomic investigations on the flora occurring in these habitats allowed the detection of two new subspecies of *Solenopsis laurentia*, both with a different autoecology.
Keywords: Apulia; Flora; *Isoeto-Nanojuncetea*; Italy; Mediterranean temporary ponds; Multivariate analysis; Phytosociology; *Solenopsis*.

Estudio fitosociológico de las charcas temporales de Apulia (sur de Italia)

Resumen. La vegetación higrófila efímera que ocurre en las charcas temporales de Apulia (Italia) ha sido estudiada desde el punto de vista fitosociológico. Sobre la base de 153 inventarios tomados durante el período 2015-2018, se identificaron 19 asociaciones, de las cuales 16 se han descrito por primera vez. Todas las asociaciones pertenecen a la clase *Isoeto-Nanojuncetea*. Se han identificado dos órdenes, *Isoetetalia*, para las comunidades con un ciclo de invierno-primavera y *Nanocyperetalia*, para aquellas con un ciclo de verano. Para cada asociación estudiada se adjunta la correspondiente tabla fitosociológica. Las comunidades pertenecientes a *Isoetetalia* son 17 y dispuestas en cuatro alianzas (*Isoetion*, *Preslion cervinae*, *Cicendio filiformis-Solenopsion laurentiae*, *Agrostion salmanticae*), mientras que las de *Nanocyperetalia* están incluidas en *Verbenion supinae*. Para resaltar las correlaciones florísticas entre las asociaciones, se procesan todos los datos relevantes utilizados para esta investigación. En general, este análisis confirma la autonomía de las asociaciones, agrupándolas de acuerdo con el arreglo sintaxonómico propuesto por los autores. Investigaciones taxonómicas sobre la flora de estos hábitats nos han llevado a la descripción de dos nuevas subespecies de *Solenopsis laurentia* con distinta autoecología.
Palabras clave: Apulia; flora; *Isoeto-Nanojuncetea*; Italia; charcas mediterráneas temporales; Analisis multivariables; fitosociología; *Solenopsis*.

Introduction

One of the extremely specialized wet habitats, occurring in Europe and southern Mediterranean territories, rich in ephemeral hydrophytes of exceptional geobotanical value, is represented by temporary ponds, which are periodically flooded by rainwater, mainly during the autumn-winter time. These surfaces remain usually submerged until the late spring and, sometimes, also in the early summer (Grillas *et al*., 2004). These very peculiar stands, characterized by silt-clay soils deposited on impermeable substrates, are colonized by ephemeral plant communities linked to temporarily submerged soils. Based on the environmental conditions, mainly regarding the flooding period, two types of plant communities can be recognized, which are seasonally well differentiated. The first group includes associations mostly characterized by microphytes showing an erect habit, with early-flowering (winter-spring), localized in stands with shallow waters drying up already in spring. The second group gathers plant communities floristically and physiognomically quite diversified

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from the previous ones, since dominated by therophytes usually with prostrate or prostate-ascending habit and showing later phenology (summer), linked to habitats submerged for a long time.

This hygrophilous vegetation for its floristic, ecological and bio-geographical peculiarities, as well as for its rarity and scattered distribution, has always drawn the attention of botanists and especially of phytosociologists. The first phytosociological investigations date back to the 20s of the last century, such as Allorge (1922), Gaume (1924a, 1924b, 1925) and Koch (1926), who examined plant communities distributed in the Central and Atlantic territories of Europe, while Braun–Blanquet (1931, 1936) surveyed those occurring in the Mediterranean area. Later, several other authors examined this vegetation in many other territories, for instance, Klika (1935), Moor (1936, 1937), Diemont *et al*. (1940), Braun-Blanquet & Tüxen (1943), Eig (1946), Molinier & Tallon (1948, 1950), Slavnic (1951), Braun-Blanquet *et al*. (1952), Rivas Goday (1955, 1964, 1970), Chevassut & Quezel (1956, 1958), Lohmeyer *et al*. (1962), Braun-Blanquet (1967), Philippi (1968), Aubert & Loisel (1971), Pietsch (1973a, 1973b), Quézel (1998), Molina (2005), Silva *et al*. (2009), Molina *et al*. (2009) who have extended the phytosociological knowledge to the most of the Mediterranean basin and European countries. More recently, in order to clarify the complex correlations within the communities linked to these wet habitats, numerous syntaxonomic treatments have been proposed, with often contrasting outcomes, especially in recognizing the ecological, floristic and chorological role of high-rank syntaxa (De Foucault, 1988; Géhu, 1992; Rivas-Martinez *et al*. 1994; Brullo & Minissale, 1998; Rivas-Martinez *et al*., 2001, 2002; Deil, 2005; Rivas-Martinez *et al*., 2011; Costa *et al*., 2012; Biondi *et al*., 2014; Mucina *et al*., 2016).

Based on these studies, the temporary ponds occurring in the Euro-Mediterranean territories can be included in a single class floristically, ecologically, and physiognomically well characterized and also differentiated from the structural point of view. This syntaxon is represented by the *Isoeto-Nanojuncetea*, class proposed by Braun-Blanquet & Tüxen (1943) as *nomen nudum* and after validated by Westoff *et al*. (1946). Within this class, two orders can be recognized, gathering communities seasonally well circumscribed and differentiated by a pool of species with habit and phenology markedly diversified, such as *Isoetetalia* Braun Blanquet 1935 and *Nanocyperetalia* Klika 1935. The first syntaxon is distributed in territories with Mediterranean bioclimate and is differentiated by ephemeral hydrophytes showing thermophilous requirements and having an early spring life cycle. The communities belonging to this order colonize oligotrophic wet soils dried up already in spring. As concerns the second syntaxon, it shows a Mediterranean-Atlantic and continental distribution occurring in territories characterized by Mediterranean and Temperate bioclimate (Rivas-Martinez *et al*., 2001). Floristically, it is differentiated by annual meso-hygrophilous species having summer-autumnal phenology, which grow on oligo-mesotrophic and eutrophic (sometimes halomorphic) soils.

As regards the environmental characteristics, concerning the type of the substrate, the flooding period, the chemical composition, conductivity and depth of water, the bioclimatic belt and the altitude, the floristic set results well diversified, allowing the detection of various groups of plant communities, that can be ascribed to different alliances. From the nomenclatural point of view, among the numerous alliances described within the two orders, only a little number is currently recognized (see Brullo & Minissale 1998, Mucina *et al*., 2016), among which in particular *Isoetion* Br.-Bl. 1935, *Preslion cervinae* Br.-Bl. ex Moor 1937, *Cicendio filiformis-Solenopsion laurentiae* Brullo & Minissale 1998, *Agrostion salmanticae* Rivas Goday 1958, *Lythrion tribracteati* Rivas Goday & Rivas Martínez 1970, which are all attributed to *Isoetetalia*, while in the *Nanocyperetalia* the following alliances are included: *Nanocyperion* Koch 1926, *Cicendion* (Rivas Goday in Rivas Goday & Borja 1961) Br.-Bl. 1967 (= *Radiolion linoidis* Pietsch 1973), *Elatino macropodae-Damasonion alismatis* de Foucault 1988, *Verbenion supinae* Slavnić 1951, *Eleocharition soloniensis* Philippi 1968 (= *Elatino-Eleocharition ovatae* Pietsch 1968), *Myosuro-Beckmannion eruciformis* Shapoval 2006.

In Italian territory, there is an extensive literature regarding the peninsula and its islands, where numerous associations, attributed to many of the alliances abovementioned, are recorded. In particular, plant communities of this class are mentioned from North Italy (Pignatti, 1952, 1957), Tuscany archipelago (Filippello & Sartori, 1981; Foggi & Grigioni, 1999; Foggi *et al*., 2006; Carta, 2008), Central Italy (Anzalone & Caputo, 1975; Pedrotti, 1982; Pedrotti *et al*., 1982; Gigante *et al*., 2013); Apulia (Ernandes *et al*., 2017); Calabria (Brullo *et al*., 2001); Sicily (Brullo & Di Martino, 1974; Brullo *et al*., 1976; Brullo *et al*., 1977; Brullo & Grillo 1978; Marcenò & Trapani, 1978; Minissale & Spampinato, 1987; Brullo *et al*., 1994; Brullo & Minissale, 1998; Minissale & Sciandrello, 2015; Minissale *et al*., 2017) and Sardinia (De Marco & Mossa, 1980; Mossa, 1987; Biondi & Bagella, 2005; Paradis & Finidori, 2005; Bagella *et al*., 2009).

On the whole, our researches, apart from improving the knowledge on the flora of these habitats, have allowed identifying in this territory nineteen associations, three of which already known for other Mediterranean countries but not yet recorded from Apulia, while sixteen are described as new associations. Finally, this work is provided by a multivariate analysis, where all the relevés used for this phytosociological study are processed.

Study area

As concerns the Apulia territory, several floristic, ecological and phytosociological contributions provide a quite complete and detailed framework on these peculiar wet habitats (Ernandes 2011, Ernandes et al. 2006, 2007, 2010a, 2010b, 2011, 2017, Ernandes & Marchiori 2012, 2013, Pesaresi et al. 2018). In order to improve this knowledge, the results of phytosociological investigations carried out in several places of Apulia region, mainly in

the southern part, corresponding to the Salento peninsula, are here provided. In particular, the surveyed localities are reported in Figure 1 and listed in Appendix 2, where are reported their coordinates. A Mediterranean pluviseasonal oceanic bioclimate characterizes the study area with thermomediterranean thermotype and dry-subhumid ombrotype (Rivas Martinez et al. 2001). As concerns the substrata, they are represented mainly by Cretaceous-Miocene limestones, often characterized by karst phenomena, and Plio-Pleistocenic calcarenites (Pieri *et al*., 1997; Sansò *et al*., 2015). The habitats colonized by plant communities belonging to *Isoeto-Nanojuncetea* are usually represented by wetlands periodically flooded by rainwater during the autumn-winter season. In the surveyed territory, they are not very frequent with a scattered distribution, occurring both along the coastal belt and inland. According to Ernandes & Marchiori (2013) and Ernandes *et al*. (2017), the wet habitats colonized by plant communities belonging to *Isoeto-Nanojuncetea* can be classified into four main types, such as:

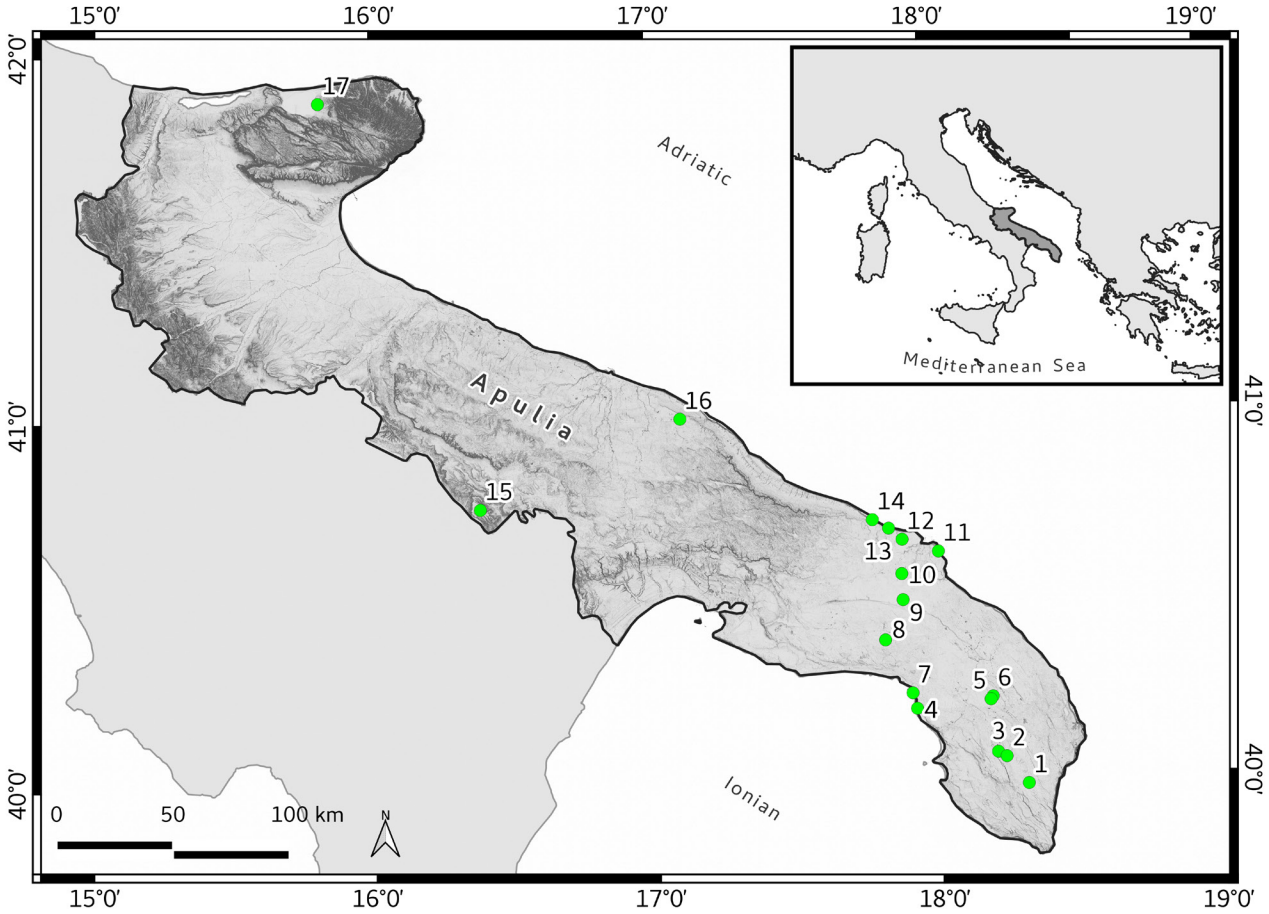

Figure. 1. Study area with surveyed localities: 1. Padula Mancina; 2. Zello; 3. Foresta; 4. Masseria Bellimento; 5. Laccu Feretru; 6. Lago del Capraro; 7. La Strea; 8. Iacorizzo; 9. Lo Specchione; 10. Bosco Preti; 11. Saline Punta della Contessa; 12. Bosco del Compare; 13. Posticeddu; 14. Torre Guaceto; 15. Lago Splendore; 16. Lago Iavorra; 17. Masseria Vigilante.

a) Cupular pools, better known as rocky pools, which are usually small catchment depression on flat outcrops arising from limestone dissolution. The bottom of these ponds is covered by a thin layer of soil, submerged by shallow water, characterized by associations regarding the *Isoetion* or *Preslion cervinae.*

b) Dolines, they are broad depressed surfaces periodically flooded by rainwater with deep and poorly permeable soils, created by karst phenomena or for subsidence. Usually, in these habitats, there are communities of the *Agrostion salmanticae* and *Verbenion supinae.*

c) Waterlogged soil, they correspond to a more or less large hollow with impermeable surfaces often localized in the wood clearing and covered by a thick layer of clay-silt soil often abundant in the sandy component. These stands are submerged by shallow rainwater for short periods, and the plant communities belong mainly to *Cicendio-Solenopsion laurentiae*.

d) Temporary streams, they are tiny and shallow watercourses, already dried up in late spring but with soils that remain moist for a long time. These habitats are infrequent and are colonized by impoverished vegetation of *Verbenion supinae.*

Materials and Methods

Floristic nomenclature

On the whole, the flora linked to the stands colonized by *Isoeto-Nanojuncetea* communities is well specialized

and usually exclusive of these wet habitats. Some of these species are cosmopolitan or subcosmopolitan, such as *Briza minor*, *Coronopus squamatus*, *Isolepis cernua*, *Juncus bufonius*, *Lythrum hyssopifolia*, *Myosurus minimus* or Euro-Mediterranean, such as *Damasonium alisma*, *Gaudinia fragilis*, *Lotus angustissimus*, *Lythrum tribracteatum*, *Mentha pulegium*, *Ranunculus ophioglossifolius*, *Ranunculus sardous*, *Trifolium dubium*, *Verbena supina*, *Veronica acinifolia*, etc. Many other species show a strictly Mediterranean distribution, among these *Agrostis pourretii*, *Anagallis parviflora*, *Isoetes todaroana*, *I. sicula*, *Lythrum thymifolia*, *Molineriella minuta*, *Pilularia minuta*, *Ranunculus saniculifolius*, *Solenopsis laurentia,* or Mediterranean-Atlantic such as *Bulliarda vaillantii*, *Callitriche brutia*, *Cicendia filiformis*, *Elatine macropoda*, *Eryngium pusillum*, *Isoetes histrix*, *I. longissima*, *Juncus capitatus*, *J. pygmaeus*, *Poa infirma.*

As concerns the floristic nomenclature, we have followed Pignatti (2017-2019) and, in some cases, also Troìa & Greuter (2015) and Bartolucci *et al*. (2018). The checklist of the species occurring in the phytosociological relevés is reported in Appendix 3. Besides, during our field survey, it was collected *Poa jubata,* a very rare species having a South-East European distribution, which is a new record from the Italian flora (Cabi *et al*., 2017, Brullo *et al.,* 2019). Another interesting finding concerns two very unusual plants belonging to *Solenopsis laurentia* cycle, which differ morphologically quite well from the typical population of this species. Basing on preliminary investigations, *Solenopsis laurentia* is a species complex, on which a taxonomic study is ongoing in order to emphasize the real role of these critical populations. For the moment, we consider it appropriate to treat them as subspecies of *S. laurentia* (L.) C.Presl and named subsp. *caespitosa* and subsp. *pusilla*. They are described in Appendix 1.

Data analysis

Vegetation data were sampled in the field between 2015 and 2018. A total of 153 relevés were carried out, according to the phytosociological approach (Braun-Blanquet, 1964; Westhoff & Der Maarel, 1978), with plot size ranging from 0.5 to 15 m^2. The surveyed localities are reported in Figure 1 and listed in Appendix 2.

The initial matrix consisted of 160 relevés x 159 species, and, in order to highlight the floristic correlations among different plant communities, the data set was subjected to multivariate analysis. Cover values were transformed according to the method proposed by Der Maarel (1979). Different clustering methods were employed, on both presence/absence and cover data, by using different combinations of distance measures (Jaccard, Euclidean, Bray-Curtis) and group linkage methods (single link, complete link, UPGMA, Flexible beta), in order to visualize the general data structure and to detect the presence of outliers. Species with a frequency lower than 2% were removed from the dataset. The resulting final data matrix consisted of 150 relevés and 127 taxa.

Hierarchical clustering on the final matrix was performed by using flexible beta linkage, with the Bray-Curtis coefficient. Beta was set at –0.25 so that flexible beta clustering became a space-conserving method (McCune & Grace, 2002). To determine the optimal number of clusters, we have used the "Optimclass 1" method ($P < 10^{-6}$) (Tichý *et al*., 2010), applying the function "Crispness of Classification" to each data set partition.

Diagnostic species of the vegetation units (partitions) were determined through the calculation of their fidelity (phi coefficient); non-significant values of phi at P = 0,005 were excluded based on Fisher's exact test (Tichy & Chytry, 2006). Then, the syntaxonomic identification of the obtained partitions was carried out on the basis of the analysis of their diagnostic species, using the author's own expert knowledge and literature.

For the ordination analyses, we carried out a Non-metric Multidimensional Scaling (NMDS) with a 'slow and thorough' option of the auto-pilot mode, using the Bray-Curtis coefficient as a dissimilarity measure (Clarke 1993). Hierarchical clustering and ordination analysis were run by PCOrd version 6.08. Optimclass and Crispness of Classification, as well as the determination of diagnostic species described above, were performed by software JUICE (Tichý, 2002).

As concerns the syntaxonomical arrangement and nomenclature aspects of the class *Isoeto-Nanojuncetea*, they based on Brullo & Minissale (1998), Weber *et al.* (2002), Biondi & Blasi (2013), Biondi *et al.* 2014, Mucina *et al.* (2016).

Results and Discussion

Within phytosociological research carried out in Apulia, a contribution concerning the plant communities belonging to *Isoeto-Nanojuncetea* class, occurring in this territory of southern Italy, is provided. Previously, this class was examined by Ernandes & Marchiori (2013) and Ernandes *et al*. (2017), who recorded several associations belonging to various alliances, such as *Isoetion*, *Preslion cervinae*, *Cicendio filiformis-Solenopsion laurentiae*, *Verbenion supinae.* Basing on personal relevés regarding the Apulian wet habitats where this peculiar vegetation occurs, it was possible to recognize numerous associations, well differentiated from the floristic and ecological point of view, most of which can be attributed to the *Isoetetalia* order since characterized by species with spring phenology, while the summer-autumnal communities of the *Nanocyperetalia* are very rare because of the lacking in the study area of large pools suitable for this vegetation kind.

The Optimclass diagram showed a peak of faithful species at 22 partitions of the data-set. Also comparing with the Optimclass diagrams obtained by other clustering methods (e.g. flexible beta, Euclidean distance; UPGMA, Bray-Curtis; UPGMA, Euclidean), the optimal partitions turn out to range from 18 to 24. Nev-

ertheless, the Crispness of Classification indicated the clearest separations at 3 and 6 clusters.

To detect plant communities and according to Optimclass analysis, the dendrogram was pruned to give 19 clusters of relevés (Figure 2). The groups thus identified correspond to the surveyed associations, wholly autonomous from a floristic and ecological point of view.

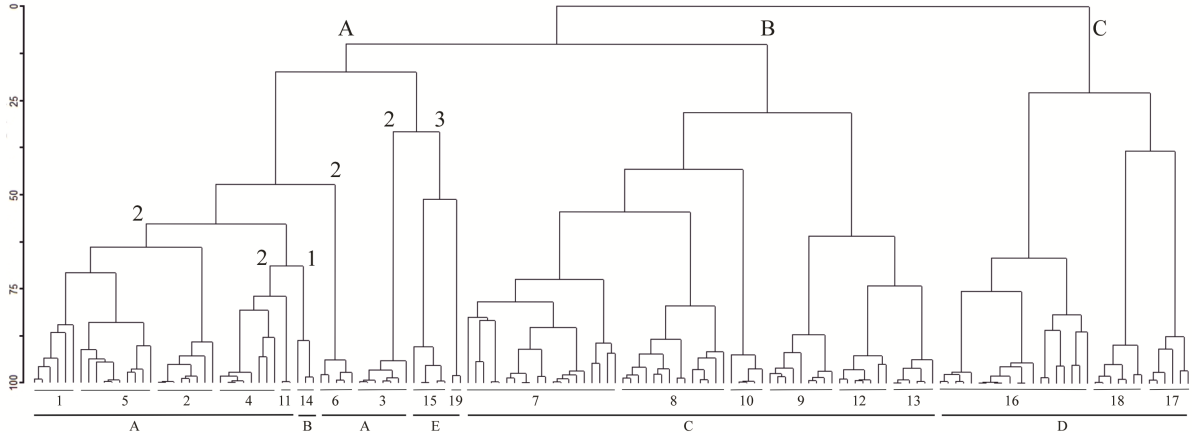

Figure 2. Dendrogram from the cluster analysis showing the associations and alliances: 1 *Isolepido cernuae-Ranunculetum saniculifoliae;* 2 *Ranunculo ophioglossifolii-Callitrichetum brutiae;* 3 *Ranunculo ophioglossifolii-Elatinetum alsinastri;* 4 *Coronopo squamati-Damasonietum polispermi;* 5 *Ranunculo saniculifolii-Elatinetum macropodae;* 6. *Pilulario minutae-Isoetetum longissimae;* 7. *Solenopsio laurentiae-Isoetetum todaroanae*; 8. *Poo jubatae-Isoetetum histricis;* 9. *Solenopsidetum caespitosae;* 10. *Radiolo linoidis-Solenopsidetum parvulae;* 11. *Triglochido laxiflorae-Isoetetum longissimae;* 12. *Anagallido parviflorae-Spergularietum arvensis;* 13. *Anagallido parviflorae-Molinerielletum minutae*; 14. *Myosuro minimi-Buillardietum vaillantii;* 15. *Damasonio alismae-Verbenetum supinae;* 16. *Phalarido minoris-Agrostidetum pourretii;* 17. *Moenchio erectae-Isoetetum siculae;* 18. *Chamaemelo mixti-Agrostidetum pourretii;* 19. *Heliotropo supini-Heleochloetum schoenoidis;* A. *Preslion cervinae*; B. *Isoetion*; C. *Cicendio filiformis-Solenopsion laurentiae*; D. *Agrostion salmaticae*; E. *Verbenion supinae.*

On the whole, from the multivariate analysis, the associations identified result quite well differentiated from each other, since arranged in distinct clusters.

Indeed, as showed in Figure 2, three main clusters can be detected, which are separated in ecological groups. The first to disjoin is cluster C, including the associations occurring mostly in doline habitats, represented by large depressed surfaces periodically flooded with deep soils, that belong to *Agrostion salmanticae.* These plant communities are physiognomically characterized by species showing a big size with high coverage values. As regards the other associations, they segregate into two distinct clusters, of which the cluster B is more homogeneous, including more or less acidophilous associations linked to waterlogged soils, localized in large hollows or woodland clearings, rich in fine sediments, and are represented by *Cicendio-Solenopsion laurentiae* communities. They are differentiated mainly by very small erect species, which show a more or less thinning coverage. Finally, cluster A turns out to be the most heterogeneous, because it includes, apart from the *Preslion cervinae* associations, which are the most represented and rich in creeping amphibian species, also that microphytic one of the *Isoetion*, both included in the subcluster A1, related to the communities growing in the cupular pools. The *Verbenion supinae* associations form a distinct cluster (A3) closely related to that one regarding the peculiar *Elatine alsinastrum* community (A2) belonging to *Preslion cervinae*, both localized in large hollows usually used as pastures, with well nitrified soils.

The NMDS ordination results in a three-axis solution, with final stress of 16.6. The three axes account for 88.7% of the variance in the Bray-Curtis dissimilarity matrix (first axis 47.8%, second axis 24.7%, and third axis 16.2%). Results of the NMDS ordination approximately confirm the general pattern highlighted by the cluster analysis. In the NMDS 3D diagram (not shown), the *Agrostidion* communities (blue triangles) sharply separate, along with axis 1, from the other alliances. Along the axis 2, the communities of *Cicendio-Solenopsion* segregate from those of *Preslion cervinae* and *Isoetion*. As already highlighted in the dendrogram, the relevés of *Isoetion* get mixed up with those of the *Preslion*, mainly because they are floristically impoverished and scarce. As regards the *Verbenion supinae* communities, they are partially mixed with those of *Preslion* and *Isoetion*, especially along the axis 1, while segregating quite well along the axis 3. This general pattern is confirmed even when considering the arrangement of the relevés at the level of individual plant communities in the NMDS 2D (axis 1-2) diagram (Figure 3).

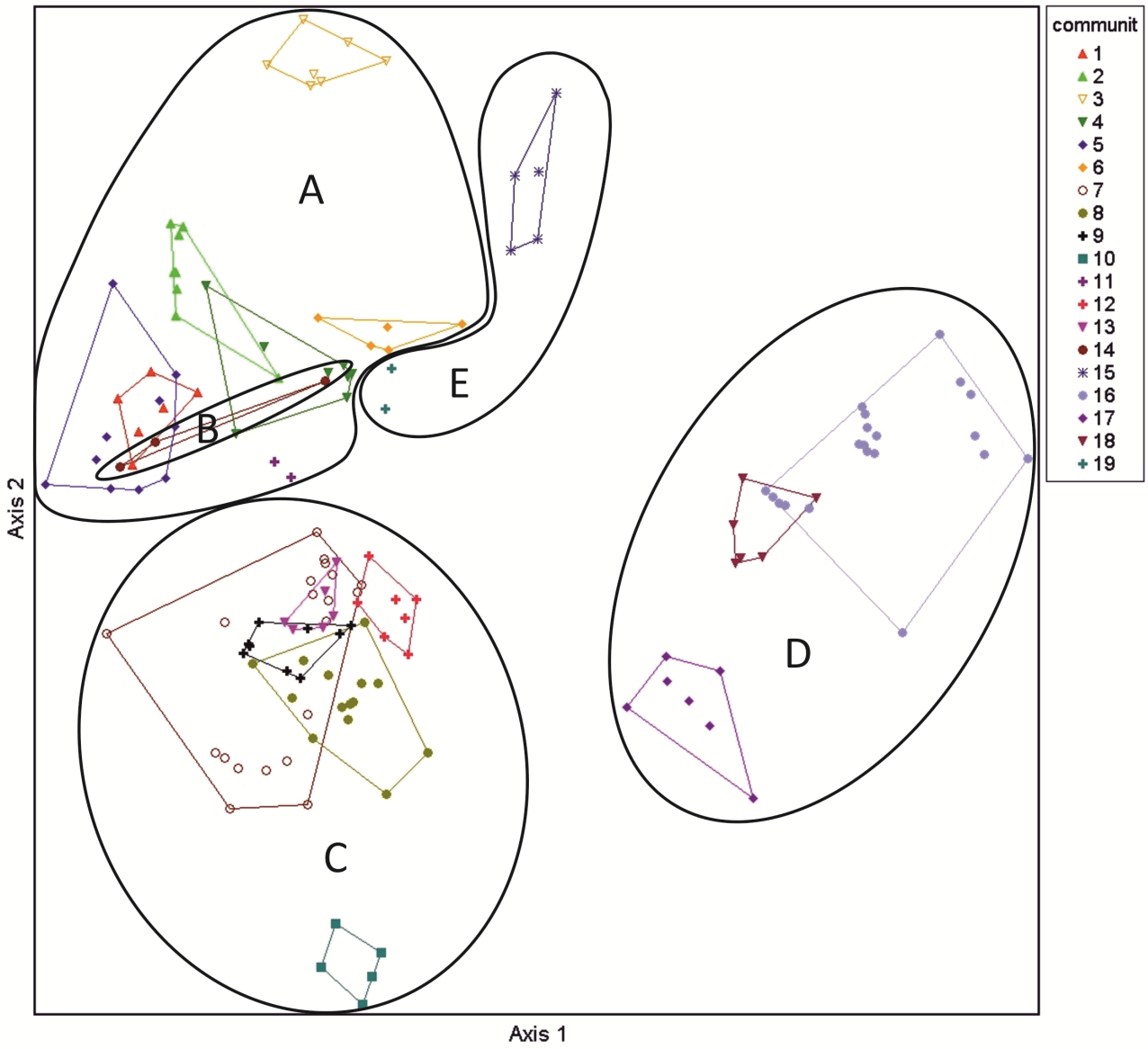

Figure 3. NMDS ordination of relevés, 2D (axis 1-2) representation of single associations and alliances: 1. *Isolepido cernuae-Ranunculetum saniculifoliae;* 2. *Ranunculo ophioglossifolii-Callitrichetum brutiae;* 3. *Ranunculo ophioglossifolii-Elatinetum alsinastri;* 4. *Coronopo squamati-Damasonietum polispermi;* 5. *Ranunculo saniculifolii-Elatinetum macropodae;* 6. *Pilulario minutae-Isoetetum longissimae;* 7. *Solenopsio laurentiae-Isoetetum todaroanae;* 8. *Poo jubatae-Isoetetum histricis;* 9. *Solenopsidetum caespitosae;* 10. *Radiolo linoidis-Solenopsidetum parvulae;* 11. *Triglochido laxiflorae-Isoetetum longissimae;* 12. *Anagallido parviflorae-Spergularietum arvensis;* 13. *Anagallido parviflorae-Molinerielletum minutae;* 14. *Myosuro minimi-Buillardetm vaillantii;* 15. *Damasonio alismae-Verbenetum supinae;* 16. *Phalarido minoris-Agrostidetum pourretii;* 17. *Moenchio erectae-Isoetetum siculae;* 18. *Chamaemelo mixti-Agrostidetum pourretii;* 19. *Heliotropo supini-Heleochloetum schoenoidis*; A. *Preslion cervinae*; B. *Isoetion*; C. *Cicendio filiformis-Solenopsion laurentiae*; D. *Agrostion salmaticae;* E. *Verbenion supinae*

As concerns the syntaxa surveyed in Apulia, they are reported in the following syntaxonomical scheme:

Isoeto-Nanojuncetea Br.-Bl. & R. Tx. ex Westhoff, Dijk & Passchier 1946
Isoetetalia Br.-Bl. 1935
Isoetion Br.-Bl. 1935
Myosuro minimi-Bulliardetum vaillantii Br.-Bl. 1935
Preslion cervinae Br.-Bl. ex Moor 1937
Isolepido cernuae-Ranunculetum saniculifolii ass. nova
Ranunculo ophioglossifolii-Callitrichetum brutiae ass. nova
Ranunculo ophioglossifolii-Elatinetum alsinastri ass. nova
Ranunculo saniculifolii-Elatinetum macropodae ass. nova
Pilulario minutae-Isoetetum longissimae ass. nova
Triglochido laxiflorae-Isoetetum longissimae ass. nova
Coronopo squamati-Damasonietum polyspermi ass. nova

Cicendio filiformis-Solenopsion laurentiae Brullo & Minissale 1998

Solenopsio laurentiae-Isoetetum todaroanae ass. nova

Solenopsidetum caespitosae ass. nova

Poo jubatae-Isoetetum histricis ass. nova

Radiolo linoidis-Solenopsidetum parvulae ass. nova

Anagallido parviflorae-Spergularietum arvensis ass. nova

Anagallido parviflorae-Molinerielletum minutae Brullo, Scelsi, Siracusa, Tomaselli 1996

Agrostion salmanticae Rivas Goday 1958

Phalarido minoris-Agrostidetum pourretii ass. nova

Moenchio erectae-Isoetetum siculae ass. nova

Chamaemelo mixti-Agrostidetum pourretii ass. nova

Nanocyperetalia Klika 1935

Verbenion supinae Slavnić 1951

Damasonio alismae-Verbenetum supinae ass. nova

Heliotropio supini-Heleochloetum schoenoidis Rivas Goday 1955

Isoeto-Nanojuncetea Br.-Bl. & R. Tx. ex Westhoff, Dijk & Passchier 1946

Syn.: *Isoeto-Nanojuncetea* Br.-Bl. & R. Tx. 1943, nom. inval. (artt. 2b, 8); *Isoeto-Nanojuncetea* Br.-Bl. & R. Tx. in Br.-Bl. et al. 1952, nom. illeg. (art. 31); *Isoetetea velatae* de Foucault 1988; *Juncetea bufonii* de Foucault 1988

Lectotypus: *Isoetetalia* Br.-Bl. 1935

Characteristic species: *Antinoria agrostidea*, *Elatine macropoda*, *Gaudinia fragilis*, *Juncus bufonius*, *J. capitatus*, *J. pygmaeus*, *Lythrum hyssopifolia*, *L. tribracteatum*, *Mentha pulegium*, *Myosurus minimus*, *Polypogon subspathaceus*, *Pulicaria vulgaris*, *Poa infirma*, *Ranunculus sardous*.

Structure and ecology: Ephemeral amphibious vegetation occurring in temporary ponds on soils periodically flooded by oligotrophic, eutrophic, or, rarely, sub-salt waters (Brullo & Minissale, 1998; Biondi *et al*., 2014). Floristically, these plant communities are dominated by hygrophilous therophytes or sometimes by small hemicryptophytes and geophytes.

Geographical distribution: The associations of this class are widespread in Europe and all Mediterranean territories.

Isoetetalia Br.-Bl. 1935

Syn.: *Isoetetalia* Br.-Bl. 1931, nom. nud. (art. 2b); *Isoetetalia durieui* Br.-Bl. 1935 corr. O. de Bolòs et al. 1990

Lectotypus: *Isoetion* Br.-Bl. 1935

Characteristic species: *Briza minor*, *Bulliarda vaillantii*, *Centaurium maritimum*, *Damasonium alisma*, *D. bourgaei*, *D. polyspermum*, *Isoetes longissima (= I. velata*), *I. todaroana* (= *I. iapygia*), *I. sicula* (= *I. subinermis*), *Isolepis cernua*, *Lotus angustissimus*, *L. parviflorus*, *Lythrum borystenichum*, *L. thymifolia*, *Marsilea strigosa*, *Molineriella minuta*, *Pilularia minuta*, *Ranunculus muricatus*, *Romulea ramiflora*, *Veronica acinifolia.*

Structure and ecology: Pioneer ephemeral vegetation with thermophilous or sub-thermophilous requirements linked to oligotrophic soils dried up in spring (Brullo & Minissale, 1998; Biondi *et al*., 2014). Usually, it is characterized by hygrophilous microphytes having an early spring blooming.

Geographical distribution: This order shows a Mediterranean and South Atlantic distribution.

Isoetion Br.-Bl. 1935

Syn.: *Isoetion* Br.-Bl. 1931, nom. nud. (art. 2b); *Isoetion durieui* Br.-Bl. 1935 corr. O. de Bolòs et al. 1990; *Antinorio agrostideae-Isoetion velatae* (Br.-Bl. 1936) de Foucault 1988; *Crassulo vaillantii-Lythrion borysthenici* de Foucault 1988; *Ophioglosso lusitanici-Isoetion histricis* de Foucault 1988.

Lectotypus: *Isoetetum duriei* Br.-Bl. 1935

Characteristic species: *Aira elegantissima*, *Isoetes histrix*, *Lotus conimbricensis*, *Polygonum romanum*, *Ranunculus trilobus*, *Riccia* sp. pl.

Structure and ecology: Pioneer and fleeting vegetation localized mainly in cupular pools rich in quillworts and microphytes with early spring blooming, linked to warm Mediterranean climate. It colonizes small surfaces represented by calcareous rocky pools with very shallow silty soils that dry up very early.

Geographical distribution: This alliance has a Mediterranean distribution.

1. *Myosuro minimi-Bulliardetum vaillantii* Br.-Bl. 1935 (Table 1, rel. 1-3)

Syn.: *Myosuro-Bulliardetum* Br.-Bl. 1935; *Myosuro-Crassuletum vaillantii* Br.-Bl. 1935, nom. mut.

Lectotypus: Rel. 2, Table pg. 156, Braun-Blanquet (1935).

Characteristic species: *Myosurus minimus*, *Bulliarda vaillantii*.

Structure and ecology: In small rocky pools of a calcareous plateau, near the coast, hygrophilous vegetation characterized by *Bulliarda vaillantii* and *Myosurus minimus* has been found. These species grow together with a few other microphytes linked to these peculiar temporary wet habitats submerged by shallow waters. For its floristic and ecological features this plant community can be referred to *Myosuro minimi-Bulliardetum vaillantii*, association described by Braun-Blanquet (1935) and also quoted by Braun-Blanquet *et al*. (1952) from southern France, where occurs in basaltic rocky pools.

Geographical distribution: In Apulia the association is very rare and seems localized in only one locality of the North Gargano area. It is recorded, other than in South France (Braun-Blanquet, 1935; Barbero *et al*., 1982), also in Spain by Rivas Goday & Ocaña García (1958) and Rivas Goday (1964).

Table 1. *Myosuro minimi-Bulliardetum vaillantii* Br.-Bl. 1936 (*Isoetion*, *Isoetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	45	45	45
Plot size (m^2)	0.5	0.5	0.5
Total cover (%)	90	90	60
Species N.	12	6	8
Relevé N.	1	2	3
Characteristics of the association			
Myosurus minimus	2	1	+
Characteristics of *Isoetion* and *Isoetetalia*			
Bulliarda vaillantii	2	4	3
Ranunculus muricatus	+	.	.
Characteristics of *Isoeto-Nanojuncetea*			
Juncus bufonius	3	2	2
Lythrum hyssopifolia	1	+	2
Mentha pulegium	2	+	1
Poa infirma	2	1	1
Coronopus squamatus	1	.	+
Other species			
Parapholis incurva	2	.	1
Trifolium resupinatum	2	.	.
Prospero autumnale	+	.	.
Romulea sp.	+	.	.

Localities: 1-3: Masseria Vigilante, Ischitella, near Varano Lake, Foggia, 24.04.2018.

Preslion cervinae Br.-Bl. ex Moor 1937

Syn.: *Preslion* Br.-Bl. 1931, nom. nud. (art. 2b); *Menthion cervinae* Br.-Bl. ex Moor 1936, nom. mut. propos. by Rivas-Martínez et al. (2002)

Holotypus: *Preslietum cervinae* Br.-Bl. ex Moor 1937

Characteristic species: *Callitriche brutia*, *Ranunculus ophioglossifolius*, *R. saniculifolius*, *Veronica anagalloides*.

Structure and ecology: Thermophilous plant communities localized in cupular pools with deep stagnant waters or in stands with deep-water runoff flooded for most of the spring. This vegetation is abundant in creeping amphibian species mixed with hygrophilous microphytes.

Geographical distribution: This alliance has a Mediterranean distribution.

2. *Isolepido cernuae-Ranunculetum saniculifolii* *ass. nova hoc loco* (Table 2, rel. 1-6)

Holotypus: Rel. 3, Table 2.

Characteristic species: *Isolepis cernua*, *Ranunculus saniculifolius*.

Structure and ecology: The association occurs in large rock pools near the sea, constituted by calcarenite substrates, which are flooded by rainwater affected by the sea aerosol. Physiognomically, it is characterized by *Ranunculus saniculifolius* and *Callitriche brutia*, rhizophytes usually growing together with *Isolepis cernua,* and some species of *Lythrum.* This vegetation seems to have its optimum in coastal stands, on rocky outcrops near salt-marshes, while it is quite rare in the inland stands.

Geographical distribution: It is quite frequent along the coast of La Strea (Porto Cesareo), while it is rare inland, as Palude Mancina (Montesano Salentino, near Lecce).

3. *Ranunculo ophioglossifolii-Callitrichetum brutiae* *ass. nova hoc loco* (Table 2, rel. 7-14)

Holotypus: Rel. 8, Table 2.

Characteristic species: *Ranunculus ophioglossifolius*, *Callitriche brutia.*

Structure and ecology: The association is localized in broad calcareous depressions characterized by deep silty-clay soils submerged for long periods by rainwaters, which are quite far from the sea. Usually, it covers the central part of the flooded surfaces where the water level is deeper. This vegetation is dominated by *Ranunculus ophioglossifolius* and *Callitriche brutia*, rhizophytes associated with *Ranunculus saniculifolius* that can reach high coverage values. For its ecology and dominance of *Callitriche brutia*, this association is related to *Ranunculo lateriflorii-Callitrichetum brutiae* Brullo & Minissale 1998, described from southern Sicily and belonging also to *Preslion cervinae*.

Geographical distribution: Currently, it seems circumscribed to a locality named Contr. Foresta near Cutrofiano (Lecce).

Table 2. *Isolepido cernuae-Ranunculetum saniculifolii ass. nova* (rel. 1-6); *Ranunculo ophioglossifolii-Callitrichetum brutiae ass. nova* (rel. 7-14) (*Preslion cervinae*, *Isoetalia*, *Isoeto-Nanojuncetea*)

Altitude (m)	1	1	1	1	1	101	110	110	110	110	110	110	110	110
Plot size (m^2)	10	6	10	1	5	5	10	10	10	10	10	10	10	5
Total cover (%)	70	90	80	80	100	100	100	100	100	100	100	100	100	100
Species N.	13	10	12	14	12	9	9	10	9	9	10	10	9	10
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Characteristics of association														
Isolepis cernua	2	2	3	3	5	2	.	.	.	.	.	.	.	.
Ranunculus ophioglossifolius	.	.	.	.	.	.	3	4	5	3	2	2	1	2
Characteristics of *Preslion cervinae*														
Ranunculus saniculifolius	3	4	4	2	2	2	2	2	3	2	5	1	1	1
Callitriche brutia	1	1	2	2	1	5	5	5	5	5	4	5	3	4
Character species of *Isoetetalia*														
Lythrum borystenicum	2	3	2	2	3	.	.	.	.	.	.	.	.	.
Bulliarda vaillantii	+	1	+	+	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoeto-Nanojuncetea*														
Juncus bufonius	1	2	1	+	1	2	2	2	2	1	1	1	2	2
Lythrum hyssopifolia	1	1	1	2	2	2	2	2	2	1	1	1	2	3
Juncus pygmaeus	.	.	.	.	2	.	3	3	3	2	3	2	4	3
Polypogon subspathaceus	1	3	2	3	1	.	.	.	.	.	.	.	.	.
Juncus capitatus	.	.	.	.	1	1	.	.	.	.	.	.	.	2
Mentha pulegium	.	.	.	1	1	.	.	.	.	.	.	.	.	2
Gaudinia fragilis	.	.	.	+	.	.	.	.	.	.	.	.	.	.
Riccia cfr. *crozalsii*	.	.	.	.	.	2	.	.	.	.	.	.	.	.
Ranunculus sardous	.	.	.	.	.	.	.	.	.	.	.	.	.	2
Other species														
Rumex sp.	2	.	1	1	.	.	+	+	.	.	+	1	1	.
Alopecurus rendlei	.	.	.	.	.	.	2	2	3	3	2	1	1	1
Lythrum junceum	.	.	.	.	.	.	1	1	1	1	+	+	2	.
Glyceria notata	.	.	.	.	.	.	.	1	1	2	2	1	.	.
Bellis annua	2	2	1	1	.	1	.	.	.	.	.	.	.	.
Symphyotrichum squamatum	1	.	1	.	1	+	.	.	.	.	.	.	.	.
Polygonum aviculare subsp. *aviculare*	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Triglochin barrelieri	+	.	.	.	+	.	.	.	.	.	.	.	.	.
Blackstonia perfoliata	.	.	.	+	.	.	.	.	.	.	.	.	.	.

Localities: 1-4: La Strea, Porto Cesareo, Lecce, 05.04.2017; 5: La Strea, Porto Cesareo, Lecce, 22.04.2018; 6: Palude Mancina, Montesano Salentino, Lecce, 06.04.2017; 7-14: Cutrofiano, c.da Foresta, Lecce, 21.04.2018.

4. ***Ranunculo ophioglossifolii-Elatinetum alsinastri*** *ass. nova hoc loco* (Table 3, rel. 1-7)

Holotypus: Rel. 2, Table 3.

Characteristic species: *Elatine alsinastrum*, *Ranunculus ophioglossifolius.*

Structure and ecology: This is a very peculiar association, which is differentiated by the occurrence of *Elatine alsinastrum*, species very rare in Italy (Pignatti, 2017, 2: 313). In Apulia this species has been recently recorded by Russo (2013) from Gargano and Ernandes & Marchiori (2013) from Salento, where it occurs in two places. In particular, the association has been described by us in a large wetland near Lecce, stand characterized by deep silty-clay soils submerged for a long time. From the phytosociological point of view, this vegetation may be attributed to its ecology and floristic set to *Preslion cervinae*, alliance here represented by *Callitriche brutia* and *Ranunculus ophioglossifolius*. Among the characteristic species of high rank are frequent *Mentha pulegium*, *Lythrum borysthenicum*, *Lotus parviflorus*, *Trifolium dubium*. As concerns the habitat colonized by this vegetation, it is much more like to those related to the communities of *Verbenion supinae*, rather than those of the *Preslion cervinae*, but the species of the first alliance are entirely missing. Previously, associations characterized by *Elatine alsinastrum* were described from Germany, as *Elatini alsinastri-Juncetum tenageiae*

Libbert 1932 and from Poland, as a community with *Elatine alsinastrum* Popiela & Fudali 1996, both referred to *Elatino-Eleocharition ovatae* Pietsch in Pietsch & Müller-Stoll 1968. Besides, Nagy *et al*. (2006) from Hungary described the *Elatinetum alsinastri*, including it within the *Nanocyperion* Koch 1926. A plant community rich in *Elatine alsinastrum* was also described from Spain by Rivas-Martinez *et al*. (1980), indicating it as *Callitricho platycarpae-Elatinetum alsinastri*, but belonging, for its ecological and floristic peculiarity, to the *Potametea* class.

Geographical distribution: Basing on the current surveys, this association occurs only at Zello near Cutrofiano.

Table 3. *Ranunculo ophioglossifolii-Elatinetum alsinastri ass. nova* (rel. 1-7), *Ranunculo saniculifolii-Elatinetum macropodae ass. nova* (rel. 8-17) (*Preslion cervinae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	115	115	115	115	115	115	115	1	1	1	1	1	1	1	1	1	1
Plot size (m^2)	5	5	5	5	5	5	5	3	4	2	2	1	1	1	1	1	1
Total cover (1=10%)	10	10	10	10	10	10	10	9	7	8	6	8	10	10	10	10	10
Species N.	9	10	9	12	11	9	9	9	14	10	15	12	7	9	10	11	10
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Characteristics of association																	
Elatine alsinastrum	2	4	4	3	3	2	2	.	.	.	.	.	.	.	.	.	.
Bulliarda vaillantii	.	.	.	.	.	.	.	4	3	4	3	4	4	5	4	4	4
Elatine macropoda	.	.	.	.	.	.	.	2	3	2	3	2	1	2	2	3	2
Characteristics of *Preslion cervinae*																	
Callitriche brutia	2	2	2	3	1	2	2	.	.	1	1	.	.	2	1	1	.
Ranunculus saniculifolius	.	.	.	.	.	.	.	1	1	+	+	1	1	+	2	2	2
Ranunculus ophioglossifolius	3	3	3	4	3	3	1	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoetetalia* and *Isoeto-Nanojuncetea*																	
Mentha pulegium	2	2	2	1	3	2	2	.	1	+	+	.	.	2	2	2	1
Lythrum borysthenicum	3	4	3	3	2	3	3	.	1	2	2	1	.	.	.	.	.
Lythrum hyssopifolia	.	.	.	.	.	.	.	2	1	1	+	+	2	2	3	2	2
Juncus bufonius	.	.	.	.	.	.	.	2	1	1	2	1	1	2	+	1	1
Polypogon subspathaceus	.	.	.	.	.	.	.	2	2	.	1	1	2	1	2	1	2
Isolepis cernua	.	.	.	.	.	.	.	2	1	.	1	1	.	.	1	1	+
Lotus parviflorus	1	.	1	+	1	1	.	.	.	.	.	.	.	.	.	1	1
Juncus pygmaeus	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	1	1
Trifolium dubium	.	+	.	+	+	1	2	.	.	.	.	.	.	.	.	.	.
Gaudinia fragilis	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.	.	.
Other species																	
Paspalum distichum	3	3	3	3	3	2	4	.	.	.	.	.	.	.	.	.	.
Alopecurus rendlei	2	1	2	1	1	1	2	.	.	.	.	.	.	.	.	.	.
Glyceria notata	1	+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.
Alisma plantago-aquatica	.	+	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium resupinatum	.	.	1	1	.	.	+	.	.	.	.	.	.	.	.	.	.
Rumex sp.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.
Bellis annua	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.
Blackstonia perfoliata	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.

Other species: *Symphyotrichum squamatum* 1, *Polygonum aviculare* subsp. *aviculare* 2 in 8; *Triglochin barrelieri* + in 10; *Plantago coronopus* + in 11.

Localities: 1-7: Cutrofiano marsh, c.da Zello, Lecce, 21.04.2018; 8-12: La Strea, Porto Cesareo, Lecce, 05.04.2017; 13-17: La Strea, Porto Cesareo, Lecce, 22.04.2018.

5. *Ranunculo saniculifolii-Elatinetum macropodae* *ass. nova hoc loco* (Table 3, rel. 8-17)

Holotypus: Rel. 16, Table 3.

Characteristic species: *Elatine macropoda*, *Bulliarda vaillantii*, *Ranunculus saniculifolius*.

Structure and ecology: This association is localized in calcarenitic rocky pools submerged up to the early spring by rainwater, weakly salty due to the marine aerosol, given their proximity to the sea. Floristically, it is differentiated by *Elatine macropoda* and *Bulliarda vaillantii*, having high coverage values and growing together with *Ranunculus saniculifolius* and several other hygrophytes of *Isoeto-Nanojuncetea.* This vegetation is replaced in the stands flooded by deeper water by the *Isolepido cernuae-Ranunculetum*

saniculifolii, with which it is often in contact. In a recent contribution, Ernandes *et al*. (2017) presented numerous relevés, from various Apulian localities, which at least in part could be attributed to this association, even though they are floristically very poor or in some cases rather heterogeneous. In fact, these relevés are mixed with moss communities and were referred to different plant communities, such as *Crassulo vaillantii-Ptychostometum capillaris* Ernandes et al. 2017, *Lythro hyssopifoliae-Crassuletum vaillantii* Bagella et al. 2009 or *Elatinetum macropodae* Br.-Bl. 1931. According to literature data (Brullo & Minissale, 1998), associations rich in *Elatine macropoda* similar to that one at issue, but well differentiated from floristic and ecological viewpoint, are: a) *Apio crassipis-Elatinetum macropodae*, described by Bagella et al. (2009) from Sardinia and belonging also to the *Preslion cervinae*; b) *Crassulo vaillantii-Elatinetum macropodae* Brullo & Minissale 1998 from Algeria, but included in the *Cicendio-Solenopsion laurentiae*; c) *Elatinetum macropodae* Br. Bl. 1935 from France, which belongs to the *Isoetion.*

Geographical distribution: This association is localized in the rocky outcrops along the coast near Porto Cesareo, where it is quite frequent at La Strea.

6. *Pilulario minutae-Isoetetum longissimae* *ass. nova hoc loco* (Table 4, rel. 1-5)

Holotypus: Rel. 3, Table 4.

Characteristic species: *Pilularia minuta*, *Isoetes longissima*, *Isoetes todaroana*, *Eleocharis multicaulis.*

Structure and ecology: This association occurs in the large temporary ponds, limitedly to small areas with deeper waters. The habitat is represented by karst depression somewhat distant from the coast, constituted by calcarenitic rocks covered with silty-clay soils. In this vegetation dominated by *Isoetes longissima*, it is localized *Pilularia minuta*, small fern very rare in the Mediterranean and also in Italy (Daoud-Bouattour *et al*., 2009; Mascia *et al*., 2013; Minissale *et al*., 2017). As concerns Apulia, it is currently reported only for two localities, such as Piano di San Martino on Gargano (Russo, 2013) and Salento near Nardò (Beccarisi *et al*., 2009; Ernandes *et al*., 2010). From the phytosociological viewpoint, the association at issue belongs to *Preslion cervinae*, for the occurrence of *Ranunculus saniculifolius* and *Callitriche brutia*, which grow together with several species of *Isoeto-Nanojuncetea*. Previously, this plant community was attributed by Ernandes *et al*. (2017) to *Junco pygmaei-Isoetetum velatae*, association described by Rivas Goday (1956) and later re-examined by Rivas Goday (1970) and Rivas-Martìnez et al. (2002), indicating it as *pilularietosum minutae* subass. nova. As concerns this attribution, it should be noted that the latter association is clearly different from that one in question both for its ecology and for the absence of *Pilularia minuta*, *Eleocharis multicaulis*, *Isoetes todaroana*, *Ranunculus saniculifolius* and *Callitriche brutia*, as well as for the occurrence of *Eryngium galioides*, *Ranunculus laterifolius*, *Preslia cervina*, *Antinoria agrostidea*, etc. From the literature data, other associations characterized by *Pilularia minuta* often growing together with *Isoetes longissima* were described for other Mediterranean territories, such as *Isoetetum setacei* Br.-Bl. 1935 (= *Peplido hispidulae-Isoetetum delilei* Br.-Bl. 1935 corr. Barkman et al. 1986) occurring in South France and Iberian peninsula, *Junco pygmaei-Pilularietum minutae* Minissale et al. 2017 from Sicily, as well as *Eryngio corniculati-Isoetetum velatae* Paradis & Finidori 2005 from Sardinia. All three associations are floristically well differentiated from the *Pilulario minutae-Isoetetum longissimae*, in particular, the first two belong to *Cicendio filiformis-Solenopsion laurentiae*, the third one instead, according to the authors (Paradis & Finidori, 2005), is to be attributed to *Isoetion*.

Geographical distribution: The association seems localized exclusively in the marsh near Masseria Bellimento (Nardò).

7. *Triglochido laxiflorae-Isoetetum longissimae* *ass. nova hoc loco* (Table 4, rel. 17-18)

Holotypus: Rel. 17, Table 4.

Characteristic species: *Isoetes longissima*, *Triglochin laxiflora*

Structure and ecology: This association is located in small and quite deep pools occurring within the large depressions with silty-clayey soils rich in a sandy component. In these stands, which remain submerged by rainwater for longer periods than the surrounding surface, the vegetation is differentiated by the dominance of *Isoetes longissima* and *Triglochin laxiflora*. This vegetation must be included in the *Preslion cervinae*, mainly for its ecological requirements, rather than from the floristic point of view. On the whole, it is floristically and ecologically well distinct from the other associations characterized by *Isoetes longissima* (=*I. velata)*, among them *Pilulario minutae-Isoetetum longissimae* previously described in another Apulian locality, as well as the *Myosotido siculae-Isoetetum velatae* Pottier-Alapetite 1952, from Tunisia and Algeria (Chevassut & Quezel, 1956), *Isoeto velatae-Crassuletum vaillantii* Poiron & Barbero 1965, from South France, *Romuleo-Isoetetum velatae* Brullo & Furnari 1996 from Cyrenaica, *Archidio-Isoetetum velatae* Brullo & Minissale 1998 from Sicily.

Geographical distribution: It is very rare and surveyed only within the clearings of cork-woods of Bosco Preti (Brindisi).

8. *Coronopo squamati-Damasonietum polyspermi* *ass. nova hoc loco* (Table 4, rel. 6-16)

Holotypus: Rel. 7, Table 4.

Characteristic species: *Damasonium polyspermum*, *Coronopus squamatus.*

Table 4. *Pilulario minutae-Isoetetum longissimae ass. nova* (rel. 1-5), *Coronopo squamati-Damasonietum polyspermi ass. nova* (rel. 6-16), *Triglochido laxiflorae-Isoetetum longissimae ass. nova* (rel. 17, 18) (*Preslion cervinae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	3	3	3	3	3	66	66	66	66	66	66	66	66	66	66	66	51	51
Plot size (m^2)	1	1	1	1	1	10	10	10	20	10	12	6	6	9	9	8	10	5
Cover (1=10%)	10	10	10	10	10	10	10	9	90	10	7	7	7	8	7	9	10	10
Species N.	12	14	15	11	13	17	19	17	17	18	6	13	8	16	14	10	12	12
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Characteristics of association																		
Pilularia minuta	2	2	3	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Eleocharis multicaulis	2	2	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Isoetes todaroana	1	+	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Damasonium polyspermum	.	.	.	.	.	3	3	2	3	2	5	3	4	2	1	2	.	.
Coronopus squamatus	.	.	.	.	.	2	3	2	2	3	.	+	.	1	.	.	.	.
Triglochin laxiflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Characteristics of *Preslion cervinae*																		
Callitriche brutia	1	1	2	1	1	1	1	2	1	1	1	1	.	1	.	.	.	.
Ranunculus ophioglossifolius	.	.	.	.	.	1	+	1	1	+	.	+	1	+	1	5	.	.
Ranunculus saniculifolius	1	+	1	1	+	.	+	1	+	+	.	.	.	.	.	.	.	.
Character species of *Isoetetalia*																		
Isoetes longissima	3	4	3	2	3	+	1	.	+	+	.	1	+	+	.	.	4	4
Bulliarda vaillantii	.	+	+	.	.	+	+	+	1	+	1	1	1	1	1	.	.	.
Lythrum borysthenicum	.	.	.	.	.	.	.	.	.	.	1	2	1	.	+	1	+	.
Characteristics of *Isoeto-Nanojuncetea*																		
Ranunculus sardous	3	2	2	2	1	4	2	3	3	3	.	.	+	1	+	+	1	1
Juncus pygmaeus	1	2	2	2	1	1	2	+	+	1	1	1	.	4	1	.	1	1
Mentha pulegium	3	2	1	2	3	2	2	3	2	1	.	1	.	+	.	.	2	2
Polypogon subspathaceus	.	.	.	+	+	2	3	2	2	3	.	+	+	+	+	1	2	2
Juncus bufonius	.	.	.	.	.	1	2	2	2	2	.	+	.	1	3	.	1	1
Poa infirma	.	.	.	.	.	2	2	1	2	2	.	1	.	1	3	.	+	1
Lythrum tribracteatum	.	.	.	.	.	2	3	2	3	3	1	1	.	1	1	1	.	.
Isolepis cernua	+	+	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Lythrum thymifolia	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+
Eryngium pusillum	2	1	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Juncus capitatus	+	+	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Lythrum hyssopifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Lotus parviflorus	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																		
Sagina apetala	.	.	.	.	.	2	1	1	1	+	.	.	.	.	.	.	.	.
Arabidopsis thaliana	.	.	.	.	.	+	+	.	+	+	.	.	.	.	.	.	.	.
Convolvulus arvensis	.	.	.	.	.	.	1	1	1	+	.	.	.	.	.	.	.	.
Epilobium sp.	.	.	.	.	.	1	+	1	1	.	.	.	.	.	.	.	.	.
Oenanthe pimpinelloides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
Alopecurus myosuroides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1
Alisma lanceolatum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.
Capsella bursa-pastoris	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.
Symphyotrichum squamatum	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.

Other species: *Ranunculus baudotii* and *Alopecurus rendlei* + in 14; *Spergularia rubra* and *Trifolium michelianum* + in 15; *Medicago ciliaris* +, *Juncus articulatus* 1, *Lythrum junceum* 2, in 16.

Localities: 1-5: Palude del Capitano, Masseria Bellimento, Nardò, Lecce, 05.04.2017; 6-10: Iacorizzo, Salice Salentino, Lecce, 22.04.2018; 11-16: Iacorizzo, Salice Salentino, Lecce, 20.04.2017; 17,18: Cork woods of Bosco Preti, Brindisi, 06.04.2017.

Structure and ecology: The association has been surveyed in vast temporary ponds with deep silty-clay soils flooded for a long time. These habitats occur in the inland calcareous plateaux, usually surrounded by vineyards. Floristically this vegetation is characterized by the dominance of *Damasonium polyspermum*, species rare in Italy hitherto known only from Sicily (Brullo & Di Martino, 1974) and Apulia (Carruggio *et al*., 2016), distributed mainly in the West Mediterranean area. This species usually grows together with *Coronopus squamatus*, *Ranunculus ophioglossifolius*, *R. sardous*, *R. saniculifolius*, *Callitriche brutia*, *Lythrum tribracteatum*, *Bulliarda vaillantii*, *Juncus pygmaeus* and several other elements of *Isoeto-Nanojuncetea.* The association at issue, for the occurrence of *Damasonium polyspermum,* shows some relationships with *Elatinetum macropodae* Br.-Bl. 1935 from South France, *Damasonio polyspermi-Ranunculetum batrachyoidis* Chevassut & Quézel 1958 from Algeria, *Pulicario-Scirpetum savii* Brullo & Di Martino 1974 from Sicily. However, these three associations are floristically well differentiated by *Coronopo squamati-Damasonietum polyspermi*; in fact they are included in the *Isoetion* and not into *Preslion cervinae* (Brullo & Minissale, 1998).

Geographical distribution: This community is very rare in Apulia, where it occurs in Iacorizzo doline, near Salice Salentino (Lecce).

Cicendio filiformis-Solenopsion laurentiae Brullo & Minissale 1998

Syn.: *Cicendion* auct. medit. non Br.-Bl. 1967; *Holotypus*: *Laurentio-Anthocerotetum dicotomi* Br.-Bl. 1935

Characteristic species: *Anagallis parviflora*, *Centunculus minimus, Cicendia filiformis*, *Hypericum australe*, *Kickxia cirrhosa*, *Ophioglossum lusitanicum*, *Radiola linoides*, *Solenopsis laurentia* subsp. *laurentia.*

Structure and ecology: Communities with acidophilus requirements, markedly more sciaphilous and hygrophilous than those of the *Isoetion*. They are localized on waterlogged soils of large hollows with waterproof surfaces, often represented by wood clearing, covered by a thick layer of clay-silt soil, often rich in a sandy component. In these stands, the hygrophilous microphytes are submerged by shallow rainwater sometimes until late spring. Mucina *et al*. (2016) synonymized this alliance with *Cicendion* (Rivas Goday in Rivas Goday et Borja 1961) Br.-Bl. 1967, and included it in *Isoetetalia.* Rivas Goday & Borja (1961) described it as suballiance of *Nanocyperion flavescentis* Koch 1926, proposing it as *Cicendenion* (sub. *Cicendion*) and considering *Cicendietum filiformis* Allorge 1922 as the nomenclature type. Later, Braun-Blanquet (1967) raises it to the alliance level, including within this syntaxon, the new association *Isoeto velatae-Cicendietum filiformis.* In particular, the *Cicendietum filiformis,* described for Northern France is characterized by a floristic set rich in elements of the *Nanocyperetalia*, such as *Isolepis setacea*, *Juncus tenuis*, *Cyperus flavescens*, *C. fuscus*, *Lythrum portula*, *Spergularia rubra*, *Sagina procumbens*, *Centaurium pulchellum*, *Gnaphalium ulginosum*, *G. luteo-album*, while the elements of *Isoetetalia* are absent. Besides, it should be noted that from the nomenclatural viewpoint, the *Radiolion linoidis* Pietsch 1973 represents a synonym of the *Cicendion* as emphasized by Brullo & Minissale (1998). The two syntaxa are floristically and ecologically perfectly overlapping, since either way the associations referred to them (incl. *Cicendietum filiformis*) have the optimum at last spring to early summer occurring in the territories with temperate bioclimate and are characterized by a peculiar pool of species such as *Centunculus minimus*, *Radiola linoides*, *Hypericum humifusum*, *Montia minor*, *Chaetonychia cymosa*, etc.

Geographical distribution: The alliance is well represented in the western and central Mediterranean area.

9. *Solenopsio laurentiae-Isoetetum todaroanae* *ass. nova hoc loco* (Table 5)

Holotypus: Rel. 16, Table 5.

Characteristic species: *Isoetes todaroana*, *Solenopsis laurentia* subsp. *laurentia*.

Structure and ecology: This association is localized on waterlogged soils near sandy coast limitedly to small depressions flooded mainly during the winter period. Waterproof soils rich in sandy components characterise these stands. Floristically, the vegetation is dominated by *Isoetes todaroana* (= *I. japygia*), which usually grows with *Solenopsis laurentia* subsp. *laurentia*, *Centunculs minimus*, *Anagallis parviflora,* and several other species of the *Isoeto-Nanojuncetea*. Recently, an association with *Isoetes todaroana* has always been described in Apulia by Ernandes *et al*. (2017) as *Pleurochaeto squarrosae-Isoetetum todaroanae* surveyed by the authors on limestone outcrops limitedly to stands with non-stagnant runoff waters. On the whole, it seems a quite heterogeneous association in which moss communities are mixed with impoverished communities of the *Isoeto-Nanojuncetea*; consequently, it should be better studied and defined under the phytosociological aspect, basing on structurally more homogeneous relevés.

Geographical distribution: Currently, it was observed in some coastal localities of Salento, such as La Strea near Porto Cesareo and Torre Guaceto near Brindisi.

10. *Solenopsidetum caespitosae* *ass. nova hoc loco* (Table 6, rel. 1-9)

Holotypus: Rel. 8, Table 6.

Characteristic species: *Solenopsis laurentia* subsp. *caespitosa*

Structure and ecology: It is a very peculiar association localised at ca. 100 m of altitude, in small wet stands with silty-clay submerged during the winter for a short time. This community is characterized by a very rare hygrophyte belonging to *Solenopsis laurentia* cycle, which is here described as *S. laurentia* subsp. *caespitosa* (see Appendix 2). It grows together with a rich set of species of the *Cicendio filiformis-Solenopsion laurentiae* and *Isoeto-Nanojuncetea,* such as *Centunculus minimus*, *Anagallis parviflora*, *Veronica acinifolia*, *Lotus parviflorus*, *L. angustissimus*, *Juncus bufonius*, *J. capitatus*, *J. pygmaeus*, etc. In more raised places, this association is usually replaced by a vegetation with less hygrophilous requirements represented by the *Anagallido parviflorae-Molinerielletum minutae.*

Geographical distribution: Basing on current data, this association occurs near Padula Mancina, located in the surroundings of Montesano Salentino (Lecce).

Table 5. *Solenopsio laurentiae-Isoetetum todaroanae ass. nova* (*Cicendion-Solenopsion laurentiae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	1	1	1	1	1	1	1	4	4	4	4	4	4	1	1	1	1	1	1	1
Plot size (m^2)	1	1	2	2	3	1	1	2	1	3	1	2	2	2	2	2	2	1	1	2
Total cover (1=10%)	10	10	10	9	10	10	10	90	90	80	90	90	90	10	10	10	10	10	10	10
Species N.	8	13	14	14	14	12	11	16	16	20	19	19	14	15	13	18	18	19	19	19
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Characteristics of association																				
Isoetes todaroana	2	2	4	3	2	3	3	+	1	3	2	3	2	4	3	4	4	3	4	2
Characteristics of *Cicendio-Solenopsion laurentiae*																				
Solenopsis laurentia subsp. *laurentia*	3	1	+	1	1	1	1	3	2	+	.	1	.	3	3	2	2	1	2	3
Centunculs minimus	.	.	.	.	+	+	1	1	+	2	1	1	1	3	2	2	1	2	2	2
Anagallis parviflora	.	.	+	1	2	+	+	1	3	2	3	2	2	2	2	.	.	.	.	.
Cicendia filiformis	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoetetalia*																				
Isolepis cernua	2	2	1	2	1	.	.	.	.	.	+	.	+	1	1	1	2	2	2	1
Lotus parviflorus	.	.	.	.	.	.	.	+	.	+	+	+	.	+	.	2	1	1	2	1
Lotus angustissimus	.	.	.	.	.	.	.	.	.	1	.	+	+	.	.	.	.	.	.	.
Lythrum thymifolia	2	.	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoeto-Nanojuncetea*																				
Juncus bufonius	2	2	2	1	2	2	2	1	+	2	2	3	1	1	1	2	2	1	1	2
Lythrum hyssopifolia	4	2	2	3	2	2	2	2	1	1	+	2	1	1	1	1	2	1	2	2
Polypogon subspathaceus	3	3	3	3	3	2	3	1	1	.	1	1	.	2	2	3	3	2	2	3
Gaudinia fragilis	.	.	1	1	.	+	.	3	2	1	2	+	.	1	.	1	1	2	2	1
Ranunculus sardous	.	2	5	5	4	3	.	.	.	.	.	1	+	.	.	2	2	3	2	4
Mentha pulegium	.	3	3	4	3	1	1	.	.	.	.	.	.	.	.	2	2	1	2	2
Juncus capitatus	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	1	+	+	1	1
Poa infirma	.	.	.	.	.	.	.	.	.	+	+	1	+	.	.	.	.	.	.	.
Juncus pygmaeus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	1
Archidium phascoides	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	.	.	.	.	.
Other species																				
Bellis annua	.	1	2	2	3	2	2	2	2	1	2	1	2	2	2	3	3	2	2	3
Trifolium resupinatum	.	1	+	1	2	1	2	1	+	.	.	.	.	1	2	2	2	1	2	2
Plantago lagopus	.	.	.	.	.	.	.	1	1	1	1	.	1	.	.	2	3	2	2	1
Triglochin barrelieri	.	1	+	+	1	.	.	.	.	.	.	.	.	.	.	2	1	1	1	1
Blackstonia perfoliata	+	.	.	.	.	.	.	.	+	1	.	1	.	+	1	.	.	.	.	.
Romulea ramiflora	.	+	+	1	+	.	.	2	+	.	.	.	.	.	.	.	.	.	.	.
Euphorbia exigua	.	.	.	.	.	.	.	.	.	+	+	+	.	1	+	.	.	.	.	.
Linum bienne	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	1	2
Plantago coronopus	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	+	1	.
Oenanthe lachenalii	.	.	.	.	.	.	.	2	.	1	1	.	.	.	.	.	.	.	.	.
Sherardia arvensis	.	.	.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.
Galium murale	.	.	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.
Prospero autumnale	.	.	.	.	.	.	.	.	.	1	1	.	1	.	.	.	.	.	.	.
Catapodium balearicum	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	.	.	.	.	.
Sagina apetala	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.
Carex flacca subsp. *serrulata*	.	.	.	.	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.
Alopecurus rendlei	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2
Parentucellia viscosa	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.

Localities: 1-7: La Strea, Porto Cesareo, Lecce, 05.04.2017; 8-13: Torre Guaceto, Carovigno, Brindisi, 07.04.2017; 14-20: La Strea, Porto Cesareo, Lecce, 22.04.2018.

11. *Poo jubatae-Isoetetum histricis* *ass. nova hoc loco* (Table 6, rel. 10-23)

Holotypus: Rel. 12, Table 6.

Characteristic species: *Isoetes histrix*, *I. sicula*, *Poa jubata*.

Structure and ecology: This association was surveyed in waterlogged soils occurring in the clearings inside the evergreen oak woodlands. The stands liked by this vegetation are represented by very long and narrow walkways, usually sheltered and shaded, which are submerged during all the winter until the early spring. The soils are silty-clay, rich in sandy components, which are entirely covered by this hygrophilous community, chiefly dominated by *Isoetes histrix*. This species grows together with several other microphytes of the *Isoeto-Nanojuncetea*,

including *Isoetes sicula*, *Centunculus minimus*, *Anagallis parviflora*, *Solenopsis laurentia* subsp. *laurentia*, *Cicendia filiformis*, *Lotus parviflorus, Polypogon subspathaceus*, *Mentha pulegium*, etc. Besides, in this association it is localized *Poa jubata,* a rare South-East Mediterranean species, new for Italian flora (Brullo *et al.*, 2019). For its floristic set, the *Poo jubatae-Isoetetum histricis* shows close relations with the *Junco capitati-Isoetetum histricis* Br.-Bl. 1935 described from North Tunisia, but these two communities differ significantly for their ecology and floristic set. Previously, Ernandes *et al*. (2017) attributed the Apulian relevés characterized by *Isoetes histrix*, usually associated with *I. sicula* (sub *I. inermis*) to the *Junco capitati-Isoetetum histricis*, recognizing four subassociations. Most of these relèves that were carried out in the same our stands are somewhat impoverished floristically (probably due to excessive shading), and therefore their phytosociological arrangement is not clear at all, while the most complete are those referred to the subass. *solenopsietum laurentiae*, that fall very well in the association by us proposed. More recently, Pesaresi *et al*. (2018) emphasizing that the Apulian relevès published by Ernandes *et al*. (2017) can not be attributed to the *Junco capitati-Isoetetum histricis*, deem that they must be treated as a new association named *Isoetetum siculae-histricis*, recognizing all the four subassociations detected by the last authors. Unfortunately, the authors choose as holotype, among the relevès published by Ernandes et al. (2017) in Tab. 4, one of the poorest floristically in which almost all the most significant species of this plant community are missing. In particular, this relevé is the nomenclatural type of subass. *isoetetosum siculae*, that as already highlighted, is not informative under the phytosociological profile and, however, wholly different from the subass. *solenopsietum laurentiae*. The last syntaxon for its floristic set and ecological requirements must be considered as a distinct association represented by *Poo jubatae-Isoetetum histricis*, clearly belonging to *Cicendio filiformis-Solenopsion laurentiae*, likewise *Junco capitati-Isoetetum histricis*.

Geographical distribution: This association is localized in wet depressions within holm and cork oak woodland near Brindisi.

12. ***Radiolo linoidis-Solenopsidetum parvulae*** *ass. nova hoc loco* (Table 7, rel. 1-5)

Holotypus: Rel. 1, Table 7.

Characteristic species: *Solenopsis laurentia* subsp. *parvula*, *Radiola linoides.*

Structure and ecology: This association was surveyed in a calcarentic rocky place near the sea, in small wet pools, within a garigue dominated by *Erica forskalii*. It occurs on silty-sandy soils flooded for short periods during the winter. Floristically, it is characterized by *Solenopsis laurentia* subsp. *parvula*, inconspicuous hygrophyte closely related to *S. laurentia*, from which it differs compared to the typical populations for its habit acaulescent, very reduced size and smaller flowers (see Appendix 2). Besides, this community is differentiated by *Radiola linoides*, a microphyte in Apulia noted only for this stands. Moreover, several elements of the *Cicendio filiformis-Solenopsion laurentiae* and *Isoeto-Nanojuncetea* are here quite frequent.

Geographical distribution: It was surveyed only in tiny pools along the rocky coast of Posticeddu (Brindisi).

13. ***Anagallido parviflorae-Spergularietum arvensis*** *ass. nova hoc loco* (Table 7, rel. 6-12)

Holotypus: Rel. 9, Table 7.

Characteristic species: *Spegularia arvensis.*

Structure and ecology: This association is localized within the moist meadows dominated by *Alopecurus rendlei,* surrounding the vast wetland colonizing by plant communities of the *Preslion cervinae.* It occurs limitedly to the small pools, which are more depressed compared to the rest of the surface, remaining flooded for a longer period. Floristically this vegetation is characterized by *Spergula arvensis*, which grows together with *Anagallis parviflora* and several species of the *Isoeto-Nanojuncetea*. It is a quite rare association observed in inland flat stands at ca. 100 m altitude within large cultivated areas.

Geographical distribution: It occurs in the wetland of Contrada Foresta (Cutrofiano).

14. ***Anagallido parviflorae-Molinerielletum minutae*** Brullo, Scelsi, Siracusa, Tomaselli 1998 (Table 7, rel. 13-18)

Holotypus: Rel. 4, Table 1, Brullo *et al*. (1998).

Characteristic species: *Molineriella minuta.*

Structure and ecology: In inland at ca. 100 m altitude on damp stands mixed to crops a very peculiar hygrophilous plant community physiognomically characterized by *Molineriella minuta* was found. In this vegetation, several species of the *Cicendio filiformis-Solenopsion laurentiae* and *Isoeto-Nanojuncetea* are frequent, such as *Anagallis parviflora*, *Centunculus minimus*, *Veronica acinifolia*, *Juncus bufonius*, *J. capitatus*, *J. pygmaeus*, *Lythrum hyssopifolia*, etc. It is localized on small, depressed surfaces with silty sandy soils, flooded only for a short period. For its ecology and occurrence of *Molineriella minuta* and *Anagallis parviflora*, this community can be referred to the *Anagallido parviflorae-Molinerielletum minutae*, the association described by Brullo *et al*. (1998) from Mount Lauro in South Sicily. On the whole, the Apulian vegetation is very similar to that one from Sicily, although floristically much more impoverished. As concerns its ecological requirements, in Apulia, the association is in contact with the *Solenopsietum caespitosae*, but it is localized in slightly more elevated stands.

Geographical distribution: This association is very rare and occurs exclusively at Padula Mancina (Montesano Salentino).

Table 6. *Solenopsidetum caespitosae ass. nova* (rel. 1-9), *Poo jubatae-Isoetetum histricis ass. nova* (rel. 10-23) (*Cicendio-Solenopsion laurentiae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	101	101	101	101	101	101	101	101	101	51	51	51	51	51	51	51	15	15	15	15	15	51	51
Plot size (m^2)	10	5	5	10	6	2	2	3	5	10	10	5	10	10	5	5	2	1	1	1	2	5	5
Total cover (%)	90	90	90	80	70	100	90	100	80	100	100	100	100	100	90	100	80	80	100	100	100	100	100
Species N.	20	19	17	19	15	20	22	22	20	21	24	24	24	22	23	21	12	12	13	14	9	24	23
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Characteristics of association																							
Solenopsis laurentia subsp. *caespitosa*	3	2	3	3	2	3	2	4	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Isoetes histrix	.	.	.	.	.	.	.	.	.	3	4	4	4	3	3	2	3	3	4	2	3	3	5
Isoetes sicula	.	.	.	.	.	.	.	.	.	1	+	+	1	+	1	1	+	1	1	1	1	1	1
Poa jubata	.	.	.	.	.	.	.	.	.	2	1	1	1	2	2	2	.	.	.	.	.	1	+
Characteristics of *Cicendio-Solenopsion laurentiae*																							
Centunculus minimus	+	1	.	1	1	2	1	2	2	1	3	2	2	1	+	1	1	+	+	2	2	1	2
Anagallis parviflora	1	1	1	+	+	2	+	1	1	2	2	2	2	1	2	1	.	+	+	2	1	+	1
Riccia cf. crozalsii	3	2	2	2	1	1	2	3	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Solenopsis laurentia subsp. *laurentia*	1	+	+	.	.	1	2	1	2	4	3	4	3	2	1	1	.	.	.	.	.	1	2
Cicendia filiformis	.	.	.	.	.	.	.	.	.	1	1	2	1	2	+	1	.	.	.	.	.	1	2
Characteristics of *Isoetetalia*																							
Lotus angustissimus	1	+	2	+	1	2	2	1	2	.	1	1	+	1	+	+	2	2	2	+	1	1	+
Lotus parviflorus	2	1	1	+	1	.	+	1	+	.	.	.	.	+	+	+	2	1	+	+	.	.	.
Veronica acinifolia	3	2	2	2	3	1	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Isolepis cernua	+	+	1	2	.	+	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lythrum borystenicum	1	.	+	1	.	1	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Briza minor	.	.	.	.	.	.	+	+	.	+	.	+	1	.	+	.	.	.	.	.	.	+	.
Isolepis cernua	.	.	.	.	.	.	.	.	.	1	+	1	+	+	2	1	.	.	.	.	.	.	.
Isoetes todaroana	.	1	+	.	.	1	1	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Centaurium maritimum	.	.	.	.	.	.	.	.	.	.	+	.	+	+	.	+	.	.	.	.	.	+	+
Archidium phascoides	.	.	.	.	.	+	2	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoeto-Nanojuncetea*																							
Polypogon subspathaceus	1	+	1	2	1	1	1	+	1	2	2	1	1	+	2	2	2	2	2	3	2	2	2
Juncus bufonius	2	3	3	2	1	1	2	2	1	+	1	+	+	1	+	+	1	.	+	1	2	+	1
Ranunculus sardous	2	1	2	2	+	1	1	+	1	3	2	2	1	2	1	1	1	1	.	+	.	2	1
Lythrum hyssopifolia	2	1	1	+	2	2	1	2	2	2	1	1	2	1	1	1	1	1	1	2	+	.	.
Juncus capitatus	1	2	2	2	+	2	2	2	1	.	1	+	1	.	.	.	.	.	.	.	.	1	2
Mentha pulegium	.	.	.	.	.	.	.	.	.	2	2	2	1	2	1	2	2	1	1	2	2	1	1
Gaudinia fragilis	.	.	.	.	.	.	.	.	.	2	1	2	1	1	1	2	1	1	.	1	.	.	.
Juncus pygmaeus	2	2	1	2	1	2	2	+	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anthoceros dichotomus	+	+	.	+	+	2	2	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium dubium	.	.	.	.	.	.	.	.	.	1	1	+	.	.	1	+						1	1
Poa infirma	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.
Other species																							
Oenanthe pimpinelloides	.	.	.	.	.	.	.	.	.	2	1	2	2	2	2	1	1	2	2	2	.	2	2
Bellis annua	.	.	.	.	.	.	.	.	.	2	3	2	1	1	1	1	.	.	.	.	.	2	1
Carex flacca subsp. *serrulata*	.	.	.	.	.	.	.	.	.	+	1	+	1	+	.	+	.	.	.	.	.	1	1
Herniaria glabra	+	1	+	1	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vulpia geniculata	.	.	.	.	.	.	.	.	.	1	1	.	.	+	+	.	.	.	.	.	.	1	2
Serapias lingua	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	1	1
Sagina apetala	.	.	.	.	.	.	.	.	.	+	+	+	+	.	.	.	.	.	.	.	.	.	.
Alopecurus rendlei	.	.	.	.	.	1	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Aira cupaniana	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	2	2
Romulea ramiflora	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	+
Myosotis ramosissima	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Erophila verna	1	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Trifolium campestre	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	2
Plantago lanceolata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	2	.	.	.	.

Other species: *Blackstonia perfoliata* + in 15; *Briza máxima* + in 22.
Localities:1-5: Palude Mancina, Montesano Salentino, Lecce, 05.04.2017; 6-9: Palude Mancina, Montesano Salentino, Lecce, 22.04.2018; 10-16: Cork woods of Bosco Preti, Brindisi, 06.04.2017; 17-21: Holm oak of Bosco del Compare, Brindisi, 06.04.2017; 22-23: Cork woods of Bosco Preti, Brindisi, 23.04.2018.

Table 7. *Radiolo linoidis-Solenopsidetum parvulae ass. nova* (rel. 1-5), *Anagallido parviflorae-Spergularietum arvensis ass. nova* (rel. 6-12), *Anagallido parviflorae-Molinerielletum minutae* Brullo, Scelsi, Siracusa, Tomaselli 1996 (rel. 13-18) (*Cicendio-Solenopsion laurentiae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	8	8	8	8	8	110	110	110	110	110	110	110	101	101	101	101	101	101
Plot size (m^2)	1	2	1	1	1	2	2	2	2	2	2	2	2	4	2	2	3	2
Total cover (%)	70	70	60	60	60	90	100	100	90	100	90	100	100	100	100	100	100	100
Species N.	13	14	13	13	12	12	13	14	12	14	14	10	18	18	15	14	14	16
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Characteristics of association																		
Solenopsis laurentia subsp. *parvula*	3	2	2	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Radiola linoides	2	2	2	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Spergula arvensis	.	.	.	.	.	3	3	3	3	4	3	2	.	.	.	.	.	.
Molineriella minuta	.	.	.	.	.	.	.	.	.	.	.	.	3	2	2	1	3	2
Characteristics of *Cicendio-Solenopsion laurentiae*																		
Anagallis parviflora	2	3	3	3	3	.	+	+	1	+	1	+	2	1	2	1	1	2
Centunculus minimus	1	+	+	.	+	.	.	.	.	.	.	.	+	+	+	.	.	1
Cicendia filiformis	2	+	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Characteristics of *Isoetetalia*																		
Briza minor	.	.	.	.	.	.	+	+	1	+	2	2	1	+	.	+	.	1
Isolepis cernua	1	+	.	+	.	.	.	.	.	.	.	.	1	+	+	.	1	+
Veronica acinifolia	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	1	.	+
Characteristics of *Isoeto-Nanojuncetea*																		
Juncus bufonius	1	+	1	2	1	3	3	3	3	2	2	4	3	3	3	2	3	3
Juncus capitatus	+	.	+	.	.	2	1	3	1	2	2	3	2	2	1	2	2	1
Ranunculus sardous	.	.	.	.	.	2	3	2	1	2	2	1	2	2	1	2	2	+
Lythrum hyssopifolia	.	.	.	.	.	2	2	1	1	1	1	2	1	+	+	1	.	1
Lotus parviflorus	.	+	1	1	1	+	1	1	+	.	+	1	.	.	.	.	.	.
Juncus pygmaeus	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	2	1
Isoetes histrix	2	+	+	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa infirma	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	1	1	1
Centaurium maritimum	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Other species																		
Alopecurus rendlei	.	.	.	.	.	2	1	2	1	2	1	2	3	3	3	4	3	3
Rumex bucephalophorus	.	.	.	.	.	2	2	1	1	2	2	1	1	1	1	1	1	+
Silene gallica	.	.	.	.	.	+	+	1	1	+	1	.	.	.	.	.	.	.
Lythrum junceum	.	.	.	.	.	.	.	.	.	.	.	.	2	2	2	1	2	2
Sagina apetala	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	+
Romulea sp.	1	2	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.
Euphorbia exigua	1	1	+	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Triglochin laxiflora	2	1	1	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Moenchia cf. mantica	2	1	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.
Ornithopus compressus	.	.	.	.	.	1	+	+	.	+	1	.	.	.	.	.	.	.
Raphanus raphanistrum	.	.	.	.	.	+	.	+	+	1	+	.	.	.	.	.	.	.
Stachys annua	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	+	.
Hypochoeris radicata	.	.	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.
Cerastium semidecandrum	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.
Coleostephus myconis	.	.	.	.	.	+	+	.	.	+	.	.	.	.	.	.	.	.

Localities: 1-5: Rocky coast near Posticeddu, Brindisi, 06.04.2017; 6-12: C. da Foresta, Cutrofiano, Lecce, 21.04.2018; 13-18 - Palude Mancina, Montesano, Lecce, 22.04.2018.

Table 8. *Phalarido minoris-Agrostidetum pourretii ass. nova* (*Agrostion salmanticae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	68	68	68	68	68	64	64	64	64	64	64	64	64	64	64	64	64	64	64	64
Plot size (m^2)	1	2	2	1	2	1	1	0.5	0.5	2	1	1	2	12	6	9	9	6	4	4
Total cover (%)	100	100	100	100	100	100	100	100	100	100	100	100	100	80	90	100	60	60	100	70
Species N.	10	12	11	11	12	11	11	12	11	10	12	12	11	7	6	4	12	9	5	6
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Characteristics of association																				
Phalaris minor	2	2	1	2	1	2	2	2	1	2	2	2	2	1	1	1	+	3	1	1
Characteristics of *Agrostion salmanticae*																				
Agrostis pourretii	5	4	5	3	3	5	4	4	5	5	4	3	3	4	5	3	2	2	1	2
Trifolium dubium	.	.	.	.	.	3	3	3	2	2	3	3	2	.	.	.	.	.	.	.
Characteristics of *Isoetetalia*																				
Eryngium pusillum	.	+	1	1	2	2	2	2	1	2	1	4	4	.	+	.	3	2	.	.
Lotus angustissimus	2	3	2	3	3	.	.	.	.	.	.	.	.	2	1	.	1	1	1	3
Characteristics of *Isoeto-Nanojuncetea*																				
Ranunculus sardous	3	3	2	3	4	3	3	3	2	3	3	4	2	.	.	.	.	.	.	.
Polypogon subspathaceus	1	2	2	2	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Briza minor	.	.	.	.	.	+	.	+	+	.	.	.	.	.	.	.	.	.	.	.
Other species																				
Carex divisa subsp. *chaetophylla*	2	3	2	1	2	3	3	2	1	3	2	1	1	+	.	4	.	+	5	.
Trifolium resupinatum	1	1	.	+	+	1	2	2	2	1	2	+	1	.	.	.	2	2	.	2
Convolvulus arvensis	.	.	.	.	.	+	1	1	2	1	+	1	1	+	+	.	1	.	.	.
Symphyotrichum squamatum	2	1	1	2	2	.	+	+	.	.	+	+	+	.	.	.	.	.	.	.
Rumex pulcher	.	.	.	.	.	1	1	1	+	1	+	1	+	.	.	.	+	.	.	.
Eleocharis multicaulis	.	.	.	.	.	3	3	2	2	3	1	1	1	.	.	.	.	.	.	.
Avena barbata	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	1	+	+	+	1
Centaurium sp.	+	+	+	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polypogon maritimus	2	2	1	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Geranium dissectum	.	+	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Poa cf. trivialis	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.
Capsella bursa-pastoris	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Chenopodium album	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.
Crepis setosa	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	.	+
Lactuca viminea	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Polygonum aviculare subsp. *rurivagum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.

Localities: 1-5: Laccu Feretru, Soleto, Lecce, 23.04.2018; 6-13: Capraro Lake, Soleto/Sternatia, Lecce, 23.04.2018; 14-20: Capraro Lake, Soleto/Sternatia, Lecce, 17.07.2017.

Agrostion salmanticae Rivas Goday 1958

Syn.: *Pre-Isoetion* Rivas Goday 1955 nom. inval. (art. 3b); *Agrostion pourretii* Rivas Goday 1958 nom. mut. propos. by Rivas-Martínez et al. (2002)

Holotypus: *Agrostio salmanticae-Pulicarietum paludosae* Rivas Goday 1955

Characteristic species: *Agrostis pourretii (= A. salmantica)*, *Chamaemelum nobile*, *C. mixtum*, *Trifolium dubium.*

Structure and ecology: Hygrophilous ephemeral vegetation rich in big size annual grasses, with high coverage values. It is localized in low depressions created by karstic phenomena (dolines) flooded by rainwater persistent during the winter and spring. These extensive stands, characterized by deep soils often rich in sands, are colonized by hygrophytes with spring blooming.

Geographical distribution: the alliance is frequent in the north-western Iberian Peninsula and central Mediterranean territories.

15. *Phalarido minoris-Agrostidetum pourretii* *ass. nova hoc loco* (Table 8)

Holotypus: Rel. 8, Table 8.

Characteristic species: *Agrostis pourretii*, *Phalaris minor.*

Structure and ecology: This association occurs on the bottom of inland karst dolines at ca. 60-70 m of altitude. flooded prevalently during the winter period, usually

settling on large surfaces with soils well developed. Physiognomically, it is dominated by annual grasses having a mainly late spring flowering, such as *Agrostis pourretii* and *Phalaris minor*, which grow together with several hygrophilous elements of the *Isoeto-Nanojuncetea*. This vegetation is usually in contact with patches of perennial herbaceous communities characterized by *Carex divisa* subsp. *chaetophylla*, often associated with *Eleocharis multicaulis*. Previously, Ernandes *et al*. (2017) treated it as *Agrostis pourretii* community, emphasizing that it requires deep syntaxonomic investigations. From the floristic and physiognomic viewpoint, the association is related to *Anthoxantho aristati-Agrostidetum salmanticae* Biondi & Bagella 2005 described from North Sardinia (Biondi & Bagella, 2005, Bagella *et al*., 2009).

Geographical distribution: The association was detected at Laccu Feretru and Lago del Capraro, near Lecce.

16. *Moenchio erectae-Isoetetum siculae* *ass. nova hoc loco* (Table 9, rel. 1-7)

Holotypus: Rel. 4, Table 9.

Characteristic species: *Isoetes sicula*, *Moenchia erecta*, *Euphorbia cuneifolia.*

Structure and ecology: This association replaces the *Phalarido minoris-Agrostidetum pourretii* in a doline localized within a woodland at ca. 450 m of altitude. Usually, it occurs at the edges of the doline where the flooding period is shorter, while in the central part vegetation characterized by the dominance of *Beckmannia eruciformis* is well developed. In this vegetation a relevant physiognomic role is played by *Isoetes sicula*, species considered by Troia & Greuter (2014, 2015) as synonym of *I. gymnocarpa* (Gennari) A. Braun, but according to Bagella *et al*. (2015), the latter is distributed in Sardinia, Corsica, Tuscany, and Balearic islands, while *I. sicula* must be considered a geographical vicariant in Sicily, South Italy, and Greece. Apart from this species, the plant community at issue is characterized by the high frequency of *Agrostis pourretii*, *Moenchia erecta,* and *Ranunculus sardous,* which grows together with other hygrophytes of the *Isoeto-Nanojuncetea*. In comparison to the previous association, it differs not only from its floristic set but also for the more marked mesophily.

Geographical distribution: It was surveyed within Difesa Grande wood at Lago Splendore, near Gravina di Puglia.

17. *Chamaemelo mixti-Agrostidetum pourretii* *ass. nova hoc loco* (Table 9, rel. 8-13)

Holotypus: Rel. 10, Table 9.

Characteristic species: *Chamaemelum mixtum*, *Cornucopiae cucullatum.*

Structure and ecology: This association, very rare and quite poor floristically, occurs near the shoreline on sandy soils in retrodunal stands in contact with salt marshes. Species dominant of this vegetation is *Agrostis pourretii*, which constitutes ephemeral grasslands, where some peculiar therophytes are localized, such as *Chamaemelum mixtum*, *Ranunculus trilobus*, and *Cornucopiae cucullatum*, this last a rare species, occurring in Italy only in a few and very localized stands (Sciandrello & Tomaselli, 2011).

Geographical distribution: This vegetation seems to be localized only at Saline Punta della Contessa (Brindisi).

Nanocyperetalia Klika 1935

Syn.: *Nanocypero-Polygonetalia* W. Kock 1926 non. nud.(2b); *Cyperetalia fusci* Müller-Stoll & Pietsch in Lohm. et al. 1962 (2b); *Cyperetalia fusci* Pietsch 1963; *Cicendietalia filiformis* Géhu 1992, nom. nud. (2b); *Elatino triandrae-Cyperetalia fusci* de Foucault 1988; *Myosuro-Beckmannietalia eruciformis* Shapoval 2006

Lectotypus: *Nanocyperion flavescentis* W. Koch ex Libbert 1932

Characteristic species: *Centaurium pulchellum*, *Cyperus fuscus, Laphangium luteoalbum*, *Sagina procumbens*, *S. subulata*, *Spergularia rubra.*

Structure and ecology: Ephemeral vegetation localized in large wet hollows usually flooded until early summer, with soils mostly eutrophic or sub-eutrophic, often hypertrophic, usually well nitrified since used as pastures, more rarely oligo-mesotrophic. Floristically it is differentiated by the occurrence of species with summer-autumn blooming, showing a prostrate and creeping habit.

Geographical distribution: This order is distributed in the Atlantic and central European territories, extending also to the Mediterranean area but limitedly to mesic habitats.

Verbenion supinae Slavnić 1951

Syn.: *Heleochloion* Br.-Bl. 1952; *Fimbristylion dichotomae* Horvatić 1954; *Dichostylidion micheliani* Horvatić 1963; *Myosurion minimi* Oberd. 1956; *Crypsio alopecuroidis-Cyperion fusci* Pietsch 1961; *Chlorocyperion glomerati* Müller-Stoll et Pietsch in T. Müller 1963; *Heleochloo-Cyperion micheliani* Pietsch et Müller-Stoll 1968; *Menthion pulegii* Lakušić in Blečić & Lakušić 1976

Lectotypus: *Heliotropio-Verbenetum supine* Slavnić 1951

Characteristic species: *Centaurium spicatum*, *Chamaesyce canescens*, *Coronopus squamatus*, *Crypsis aculeata*, *Eryngium pusillum*, *Gnaphalium uliginosum*, *Heleochloa alopecuroides*, *H. schoenoides*, *Heliotropium supinum*, *Paspalum distichum*, *Pulicaria sicula*, *Teucrium campanulatum*, *Verbena supina.*

Structure and ecology: Ephemeral vegetation occurring in large depressions subjected to long periods of submersion usually until early summer, characterized by well nitrified soils. In these habitats, flooded by eutrophic or hypertrophic water, prostrate-creeping species, often of large size, having a summer-autumnal blooming are frequent.

Geographical distribution: The communities of this alliance are spread in central-eastern Europe and also in the Mediterranean area.

Table 9. *Moenchio erectae-Isoetetum siculae ass. nova* (rel. 1-7), *Chamaemelo mixti-Agrostidetum pourretii ass. nova* (rel. 8-13) (*Agrostion salmanticae*, *Isoetetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	460	460	460	460	460	460	460	2	2	2	2	2	2
Plot size (m^2)	2	2	3	2	2	1	2	10	15	10	15	10	10
Total cover (%)	100	100	100	100	100	100	100	100	100	90	95	80	70
Species N.	22	19	23	23	18	17	19	17	19	16	15	12	10
Relevé N.	1	2	3	4	5	6	7	8	9	10	11	12	13
Characteristics of association													
Isoetes sicula	3	3	2	4	3	4	3	.	.	.	.	.	.
Moenchia erecta	3	2	3	2	2	2	3	.	.	.	.	.	.
Euphorbia cuneifolia	1	1	1	2	1	+	+	.	.	.	.	.	.
Chamaemelum mixtum	.	.	.	.	.	.	.	1	2	2	3	1	+
Cornucopiae cucullatum	.	.	.	.	.	.	.	2	1	1	.	.	.
Characteristics of *Agrostion salmanticae*													
Agrostis pourretii	3	3	3	2	3	2	2	5	4	4	5	4	3
Trifolium dubium	2	2	2	1	2	1	+	.	.	.	.	.	.
Characteristics of *Isoetetalia*													
Anagallis parviflora	2	1	2	1	2	1	2	.	.	.	.	.	.
Lotus parviflorus	2	2	2	1	1	+	1	.	.	.	.	.	.
Ranunculus trilobus	.	.	.	.	.	.	.	2	3	4	1	2	3
Bulliarda vaillantii	+	.	+	+	.	.	.	.	.	.	.	.	.
Characteristics of *Isoeto-Nanojuncetea*													
Juncus bufonius	1	+	1	1	+	.	1	3	4	3	2	2	1
Ranunculus sardous	3	2	2	2	3	1	+	.	.	.	.	.	.
Juncus capitatus	+	+	+	1	.	+	+	.	.	.	.	.	.
Mentha pulegium	1	+	+	1	+	.	+	.	.	.	.	.	.
Lythrum tribracteatum	.	.	.	.	.	.	.	1	+	1	+	2	2
Briza minor	.	.	.	.	.	.	.	+	1	+	1	.	.
Other species													
Sherardia arvensis	1	2	1	+	2	2	2	.	.	.	.	.	.
Carex divisa subsp. *chaetophylla*	2	2	2	1	2	1	1	.	.	.	.	.	.
Anthoxantum odoratum	2	1	1	2	2	1	1	.	.	.	.	.	.
Cerastium semidecandrum	2	1	+	1	1	.	+	.	.	.	.	.	.
Oenanthe lachenalii	1	1	1	1	.	1	+	.	.	.	.	.	.
Prospero autunnale	1	1	1	1	.	+	+	.	.	.	.	.	.
Spergula arvensis	.	.	.	.	.	.	.	+	+	+	1	1	+
Spergularia rubra	.	.	.	.	.	.	.	1	1	+	+	+	+
Poa trivialis	2	1	2	2	1	.	.	.	.	.	.	.	.
Cerastium glomeratum	1	+	1	+	+	.	.	.	.	.	.	.	.
Cynodon dactylon	.	.	.	.	.	.	.	1	1	+	+	+	.
Phalaris paradoxa	.	.	.	.	.	.	.	+	+	.	+	+	+
Silene gallica	.	.	.	.	.	.	.	+	+	+	1	+	.
Anagallis arvensis	.	.	.	.	.	.	.	.	.	+	1	+	+
Galium parisiense	+	.	.	.	+	1	1	.	.	.	.	.	.
Vulpia geniculata	.	.	1	+	1	+	.	.	.	.	.	.	.
Serapias lingua	.	.	1	1	.	+	+	.	.	.	.	.	.
Rumex acetosella	.	.	.	.	.	.	.	.	+	+	2	.	+
Sagina apetala	+	.	+	+	.	.	.	.	.	.	.	.	.
Glebionis segetum	.	.	.	.	.	.	.	+	+	.	+	.	.
Polypogon monspeliensis	.	.	.	.	.	.	.	+	+	.	1	.	.
Rumex crispus	.	.	.	.	.	.	.	+	1	1	.	.	.
Lolium rigidum	.	.	.	.	.	.	.	+	1	+	.	.	.
Polygonum aviculare subsp. *aviculare*	.	.	.	.	.	.	.	.	.	+	.	1	.
Echium plantagineum	.	.	.	.	.	.	.	+	+	.	.	.	.
Trifolium arvense	.	.	.	.	.	.	.	.	+	.	.	.	.

Localities: 1-7: Difesa Grande wood, Splendore Lake, Gravina di Puglia, Bari, 25.04.2018; 8-13: Punta della Contessa saltworks, Brindisi, 20.05.2015.

18. *Damasonio alismae-Verbenetum supinae* *ass. nova hoc loco* (Table 10, rel. 1-5)

Holotypus: Rel. 2, Table 10.

Characteristic species: *Damasonium alisma.*

Structure and ecology: The association occurs in large depression submerged by rainwater for a long period, often until the early summer. The soil is slightly compacted and well nitrified by heavy grazing, that affects it until the summer. The vegetation is quite poor floristically and is dominated by some annual prostrate species, having their vegetative optimum in the summer-autumnal period. In particular, the more frequent are *Verbena supina*, *Coronopus squamatus*, *Damasonium alisma,* and *Paspalum distichum*. From the literature (Brullo & Minissale, 1998), other associations rich in *Verbena supina* are represented by the *Helitropio-Verbenetum supinae* Slavnic 1951, *Glino-Verbenetum supinae* Rivas Goday 1970 and *Verbenetum supinae* Sunding 1972.

Geographical distribution: It was detected at Lago Iavorra near Conversano.

19. *Heliotropio supini-Heleochloetum schoenoidis* Rivas Goday 1955 (Table 10, rel. 6-7)

Holotypus: Rel. 3, Table 14, Rivas Goday (1955).

Characteristic species: *Heliotropium supinum*, *Heleochloa schoenoidis.*

Structure and ecology: A very poor floristically plant community characterized by *Heliotropium supinum* and *Heleochloa schoenoides*, with more hygrophilous requirement compared to the previous association, was surveyed in other wetlands. Previously this association, belonging to *Verbenion supinae* too, was recorded from Spain (Rivas-Martinez *et al*., 2002) and Sicily (Brullo & Marcenò, 1974; Brullo *et al*., 2002; Sciandrello, 2009).

Geographical distribution: Currently, it was surveyed at Lo Specchione near Brindisi, but probably it occurs also in other Apulian wetlands.

Table 10. *Damasonio alismae-Verbenetum supinae ass. nova* (rel. 1-5), *Heliotropio supini-Heleochloetum schoenoidis* Rivas Goday 1955 (rel. 6-7), (*Verbenion supinae*, *Nanocyperetalia*, *Isoeto-Nanojuncetea*)

Altitude (m asl)	140	140	140	140	140	74	74
Plot size (m^2)	5	5	10	5	5	14	16
Total cover (%)	80	90	90	90	80	70	70
Species N.	15	16	16	14	14	9	13
Relevé N.	1	2	3	4	5	6	7
Characteristics of association							
Damasonium alisma	1	3	2	2	1	.	.
Heliotropium supinum	.	.	.	.	.	2	1
Characteristics of *Verbenion supinae*							
Verbena supina	2	3	3	2	3	.	.
Coronopus squamatus	1	2	2	1	1	.	.
Paspalum distichum	2	1	1	.	.	.	.
Heleochloa schoenoides	.	.	.	.	.	+	1
Characteristics of *Nanocyperetalia*							
Spergularia rubra	1	+	+	1	2	.	.
Characteristics of *Isoeto-Nanojuncetea*							
Lythrum hyssopifolia	2	1	1	+	+	.	.
Juncus bufonius	.	+	+	1	1	.	.
Lythrum tribracteatum	.	.	.	.	.	+	2
Mentha pulegium	.	.	.	.	.	1	3
Polypogon subspathaceus	.	.	.	.	.	2	2
Other species							
Rumex conglomeratus	1	2	2	2	2	+	1
Sagina apetala	1	+	1	+	1	.	.
Polygonum aviculare subsp. *aviculare*	1	1	1	+	1	.	.
Lotus ornithopodioides	1	1	+	+	1	.	.
Cynodon dactylon	3	3	3	4	3	.	.
Phalaris minor	2	1	+	+	1	.	.
Verbena officinalis	2	+	+	1	1	.	.
Convolvulus arvensis	.	+	1	1	+	.	.
Arenaria leptoclados	2	1	+	.	.	.	.
Eleocharis palustris	.	.	.	.	.	4	1
Symphyotrichum squamatum	.	.	.	.	.	+	1
Xanthium orientale subsp. *italicum*	.	.	.	.	.	1	1
Elymus repens	.	.	.	.	.	.	1
Juncus articulatus	.	.	.	.	.	.	2
Phalaris coerulescens	.	.	.	.	.	.	+
Dittrichia viscosa	.	.	.	.	.	.	+
Parentucellia latifolia	+	.	.	.	.	.	.

Localities: 1-5: Iavorra Lake, Conversano, Bari, 07.04.2017; 6-7: Lo Specchione, Brindisi, 30.06.2017.

Conclusions

The *Isoeto-Nanojuncetea* class in Apulia is represented by several associations, well differentiated from the floristic-structural and ecological point of view, which are taxonomically arranged in five alliances. This more or less marked autonomy of these associations is emphasized by the multivariate analysis carried out on all the phytosociological relevés.

The plant communities are localized in very peculiar and specialized temporary ponds and are usually characterized by rare and endangered species. As already highlighted by other authors (Ernandes & Marchiori, 2013; Bagella *et al*., 2016), this natural heritage, highly vulnerable and threatened by various anthropic pressures, sometimes deserves specific and urgent conservation strategies.

These Mediterranean wet habitats are characterized by a high level of biodiversity, regarding both plants and animals (many of which are often endemic), where it is possible to observe an alarming rate of loss and alteration due to their easy degradability.

According to the Habitats Directive, the Mediterranean temporary ponds are considered as habitats of Community Interest and placed in group 31 (Standing Waters). In particular, the associations belonging to *Isoeto-Nanojuncetea*, such as those recorded in Apulia, fall within the priority habitat 3170*, gathering all the orders and alliances of this class. These syntaxa, always in agreement with the Habitats Directive, are also included in the habitat 3120 or 3130, differentiating them only on ecological features. This treatment is quite ambiguous and not easy to interpret, although an attempt was made by Bagella *et al*. (2007), although questionable as well.

On the whole, the temporary ponds represent highly vulnerable habitats, mainly due to their fragile hydrologic regimes and to occupy small surfaces. In fact, many anthropic factors threaten the ecological balance of these wetlands (Zacharias *et al*., 2007), such as crop intensification, variations of land use, water mobilization, landfill, overgrazing, and fire.

The conservation of a network of temporary ponds with different hydroperiods depends primarily on shrewd environmental management, where the natural hydrologic regimes, and not intensive land use it could preserve its integrity for the behoof of the future generations.

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Appendix 1. Taxonomical notes

Solenopsis laurentia (L.) C.Presl subsp. *caespitosa* Brullo subsp. nov.
Diagnosis – It differs from type for the habit caespitose, subcaulescent, erect-ascending, with many branches at the base, larger leaves arranged in a dense basal rosette, leaf petiole, floral pedicels and bracteoles longer, many-flowered, calyx 3.5-4 mm long, corolla 4.5-5 mm long, with two upper lobes 2.1-2.5 mm long and three lower lobes 1-1.2 mm long, papillae clavate, 0.1-0.3 mm long, staminal filament 2.4-2-6 mm long, capsule 3-3.2 mm long.
Holotype: Italy, Apulia, wet pools at Palude Mancina near Montesano Salentino, Lecce, 05.04.2017, L. Beccarisi, S. Brullo, P. Minissale, V. Tomaselli, G. Veronico, s.n. (CAT).

Solenopsis laurentia (L.) C.Presl subsp. *parvula* Brullo subsp. nov.
Diagnosis – It differs from type for the smaller size (1.5-2.5 cm tall), habit contract with basal leaves rosulate, crowded, spathulate, floral pedicels and bracteoles shorter, corolla 3.5-3.6 mm long, with papillae 0.05-0.2 mm long, capsule 2.5-3 mm long.
Holotype: Italy, Apulia, wet pools along the rocky coast near Posticeddu, Brindisi, 06.04.2017, L. Beccarisi, S. Brullo, P. Minissale, V. Tomaselli. s.n. (CAT).

Appendix 2. The surveyed Apulian localities, where the *Isoeto-Nanojuncetea* communities occur.

Locality	Commune	Latitude	Longitude.	Altitude (m asl)
Bosco del Compare	Brindisi	40° 39' 31"	17° 53' 16"	15
Bosco Preti	Brindisi	40° 33' 55"	17° 52' 59"	51
Foresta	Cutrofiano	40° 04' 25"	18° 12' 18"	110
Iacorizzo	Salice Salentino	40° 23' 12"	17° 49' 04"	66

La Strea	Porto Cesareo	40° 14’ 26”	17° 54’ 33”	1
Laccu Feretru	Soleto	40° 13’ 01”	18° 11’ 07”	68
Lago del Capraro	Soleto/Sternatia	40° 13’ 29”	18° 11’ 35”	64
Lago Iavorra	Conversano	41° 00’ 08”	17° 06’ 16”	140
Lago Splendore	Gravina in Puglia	40° 45’ 54”	16° 22’ 57”	460
Lo Specchione	Brindisi	40° 29’ 40”	17° 53’ 05”	74
Masseria Bellimento	Nardò	40° 11’ 53”	17° 55’ 24”	3
Masseria Vigilante	Ischitella	41° 52’ 28”	15° 48’ 46”	45
Padula Mancina	Montesano Salentino	39° 59’ 08”	18° 18’ 35”	101
Posticeddu	Brindisi	40° 41’ 24”	17° 50’ 27”	8
Saline Punta della Contessa	Brindisi	40° 37’ 25”	18° 00’ 58”	2
Torre Guaceto	Carovigno	40° 42’ 52”	17° 47’ 02”	4
Zello	Cutrofiano	40° 03’ 39”	18° 14’ 05”	115

Appendix 3. Checklist of the species occurring in the relevés.

Agrostis pourretii Willd.
Aira cupaniana Guss.
Alisma lanceolatum With.
Alisma plantago-aquatica L.
Alopecurus myosuroides Huds.
Alopecurus rendlei Eig
Anagallis arvensis L.
Anagallis parviflora Hoffmanns. & Link
Anthoceros dichotomus Raddi
Anthoxantum odoratum L.
Arabidopsis thaliana (L.) Heynh.
Archidium phascoides Brid.
Arenaria leptoclados (Rchb.) Guss.
Avena barbata Pott ex Link
Bellis annua L.
Blackstonia perfoliata Hudson
Briza maxima L.
Briza minor L.
Bulliarda vaillantii (Willd.) DC.
Callitriche brutia Petagna
Capsella bursa-pastoris (L.) Medik.
Carex divisa Huds. subsp. *chaetophylla* (Steud.) Nyman
Carex flacca Schreb. subsp. *serrulata* (Biv.) Greuter
Catapodium balearicum (Willk.) H.Scholz
Centaurium maritimum (L.) Fritsch
Centunculs minimus L.
Cerastium glomeratum Thuill.
Cerastium semidecandrum L.
Chamaemelum mixtum (L.) All.
Chenopodium album L.
Cicendia filiformis (L.) Delarbre
Coleostephus myconis (L.) Cass. ex Rchb. f.
Convolvulus arvensis L.
Cornucopiae cucullatum L.
Coronopus squamatus (Forssk.) Asch.
Crepis setosa Haller fil.
Cynodon dactylon (L.) Pers.
Damasonium alisma Mill.
Damasonium polyspermum Coss.
Dittrichia viscosa (L.) Greuter.
Echium plantagineum L.
Elatine alsinastrum L.
Elatine macropoda Guss.
Eleocharis multicaulis (Sm.) Desv.
Eleocharis palustris (L.) Roem. et Schult.
Elymus repens (L.) Gould
Erophila verna (L.) DC.
Eryngium pusillum L.
Euphorbia cuneifolia Guss.
Euphorbia exigua L.
Galium murale (L.) All.
Galium parisiense L.
Gaudinia fragilis (L.) P.Beauv.
Geranium dissectum L.
Glebionis segetum (L.) Fourr.
Glyceria notata Chevall.
Heleochloa schoenoides (L.) P.M. Peterson
Heliotropium supinum L.
Herniaria glabra L.
Hypochoeris radicata L.
Isoetes histrix Bory
Isoetes longissima Bory
Isoetes sicula Tod.
Isoetes todaroana Troìa & Raimondo
Isolepis cernua (Vahl) Roem. & Schult.
Juncus articulatus L.
Juncus bufonius L.
Juncus capitatus Weigel
Juncus hybridus Brot.
Juncus pygmaeus Rich. ex Thuill.
Lactuca viminea (L.) J. & C. Presl
Linum bienne Mill.
Lolium rigidum Gaudin
Lotus angustissimus L.
Lotus ornithopodioides L.
Lotus parviflorus Desf.

Lythrum borysthenicum (Schrank) Litv.
Lythrum hyssopifolia L. *Lythrum junceum* Banks & Sol.
Lythrum thymifolia L.
Lythrum tribracteatum Salzm. ex Spreng.
Medicago ciliaris (L.) All.
Mentha pulegium L.
Moenchia cfr mantica (L.) Bartl.
Moenchia erecta (L.) G. Gaertn. B. Mey. & Scherb.
Molineriella minuta (L.) Rouy
Myosotis ramosissima Rochel
Myosurus minimus L.
Oenanthe lachenalii C.C.Gmel.
Oenanthe pimpinelloides L.
Ornithopus compressus L.
Parapholis incurva (L.) C.E.Hubb.
Parentucellia latifolia (L.) Caruel
Parentucellia viscosa (L.) Caruel
Paspalum distichum L.
Phalaris coerulescens Desf.
Phalaris minor Retz.
Phalaris paradoxa L.
Pilularia minuta Durieu
Plantago coronopus L.
Plantago lagopus L.
Plantago lanceolata L.
Poa infirma Kunth
Poa jubata Kern
Poa trivialis L.
Polygonum aviculare L. subsp. *aviculare*
Polygonum aviculare L. subsp. *rurivagum* (Jord. ex Boreau) Berher
Polypogon maritimus Willd.
Polypogon monspeliensis (L.) Desf.
Polypogon subspathaceus Req.
Prospero autumnale (L.) Speta.
Radiola linoides Roth
Ranunculus baudotii Godr.
Ranunculus muricatus L.
Ranunculus ophioglossifolius Vill.
Ranunculus saniculifolius Viv.
Ranunculus sardous Crantz
Ranunculus trilobus Desf.
Raphanus raphanistrum L.
Riccia cfr. *crozalsii* Levier
Romulea ramiflora Ten.
Rumex acetosella L.
Rumex bucephalophorus L.
Rumex conglomeratus Murray
Rumex crispus L.
Rumex pulcher L.
Sagina apetala Ard.
Serapias lingua L.
Sherardia arvensis L.
Silene gallica L.
Solenopsis laurentia (L.) C.Presl subsp. *caespitosa*
Solenopsis laurentia (L.) C.Presl subsp. *laurentia*
Solenopsis laurentia (L.) C.Presl subsp. *parvula*
Spergula arvensis L.
Spergularia rubra (L.) J. Presl & C. Presl
Stachys annua (L.) L.
Symphyotrichum squamatum (Spreng.) G.L. Nesom
Trifolium arvense L.
Trifolium campestre Schreb.
Trifolium dubium Sibth.
Trifolium michelianum Savi
Trifolium resupinatum L.
Triglochin barrelieri Loisel.
Triglochin laxiflora Guss.
Verbena officinalis L.
Verbena supina L.
Veronica acinifolia L.
Vulpia geniculata (L.) Link.
Xanthium orientale L. subsp. *italicum* (Moretti) Greuter